

DEPARTMENT OF THE INTERIOR

REPORT

OF THE

CHIEF ASTRONOMER

FOR THE

YEAR ENDING MARCH 31

1909

PRINTED BY ORDER OF PARLIAMENT



OTTAWA

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REPORT

OF THE

CHIEF ASTRONOMER AND INTERNATIONAL BOUNDARY COMMISSIONER.

DEPARTMENT OF THE INTERIOR,

DOMINION ASTRONOMICAL OBSERVATORY,

OTTAWA, CANADA, May 1, 1909.

W. W. CORY, Esq.,
Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to present the report of the Astronomical Branch of the Department of the Interior for the year ending 31st March, 1909.

The correspondence in the twelve months was:—

| | |
|----------------------------|-------|
| Letters received. | 1,841 |
| Letters sent. | 2,997 |
| Accounts examined. | 815 |

The work of the photographer was as follows:—

| | | |
|---|-------|-------|
| Survey plates (developed), 8 x 10 | 360 | |
| “ “ 11 x 14 | 40 | |
| “ “ 16 x 20 | 161 | |
| “ “ 4½ x 6½ | 1,158 | |
| | | 1,719 |
| Films “ 3½ x 5½ | 180 | |
| “ “ 5 x 7 | 1,104 | |
| “ “ 4½ x 6½ | 120 | |
| | | 1,404 |
| Bromide prints “ 4 x 14 | 24 | |
| “ “ 11 x 14 | 1,208 | |
| “ “ 16 x 20 | 527 | |
| “ “ 9 x 36 | 469 | |
| “ “ 12 x 30 | 61 | |
| “ “ 24 x 36 | 69 | |
| “ “ 20 x 24 | 23 | |
| | | 2,381 |
| Blue prints “ 24 x 36 | 10 | 10 |
| Contact prints “ 4 x 6 | 531 | |
| “ “ 5 x 7 | 3,338 | |
| “ “ 8 x 10 | 189 | |
| | | 4,058 |
| Transparencies “ 4 x 5 | 137 | 137 |
| | | 9,709 |

Total. 9,709

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The Library on March 31st last contained 3,400 volumes and 260 pamphlets. It increases by several hundred volumes each year, principally by exchanges with other observatories and by the binding into volumes of the scientific periodicals, so that additional shelf space will be needed before very long. A card index of subjects and authors has been installed which has proved a great convenience.

The mechanical parts of a single-prism spectrograph designed by Mr. Plaskett for the avoidance of flexure, and of the solar spectrograph, of 23 feet focus, to be used in connection with the coelostat, have been constructed in the workshop.

The pivots of the meridian circle, as received from the makers, having been found to be of too soft metal, rings of hardened steel were shrunk upon them, and turned to proper form. This was a very difficult piece of work on account of the extreme accuracy of figure which was required.

There were besides numerous small pieces of work for the Observatory, and many repairs and minor alterations to field instruments for the Boundary and Geodetic Surveys, keeping two mechanics constantly employed.

The equipment of the shop has been increased by a second lathe, avoiding thereby a considerable loss of the men's time. The workshop, which is in the basement of the building, is insufficiently lighted for the fine work which we require. It is also rather inconveniently small.

The practice of opening the Observatory to the public every Saturday evening has been continued, and is much appreciated. An astronomer is always present on that evening to exhibit the large telescope. There are also many day-time visitors to the Observatory who have then an opportunity of seeing the other instruments.

The number of visitors registering in the book from April 1, 1908, to March 31, 1909, is 2,646.

In this connection may be mentioned the meetings of the Royal Astronomical Society of Canada which are held monthly during the winter in the Normal School Hall or in the Public Library, when lectures on astronomical subjects are presented. The majority of these lectures have been given by officers of the Observatory. Lectures are also given in the Observatory in the afternoon, alternating with the evening lectures in the city. These afternoon meetings serve a very useful purpose in the exchange of ideas among members of the staff.

TIME SERVICE.

The ordinary work in connection with the time service has consisted, as in the past, of the necessary attention to the up-town service, the sending out of time signals to the telegraph company, dropping of the time-ball on Parliament Hill, supplying of mean and sidereal time by telephone to those requiring it, occasional rating of chronometers, testing of aneroid barometers, &c., together with the maintenance of the clocks and apparatus at the Observatory. The city service has been extended by the installation of electric dials in the Mint and the Archives Building, which are operated by a master clock in the Mint controlled directly from the Observatory. The dials were started at noon on September 19, though the master clock was not put under control for some time subsequently. It was decided by the Public Works Department, contrary to the original intention, not to instal clocks in the Printing Bureau at present. There were also, as usual, changes and additions in the other Government Buildings. Below is a list of the number of clocks in operation:—

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MINUTE DIALS.

| | March 31, 1909. | March 31, 1908. |
|---|--------------------|--------------------|
| Parliament Building. | 49 | 46 |
| East Block. | 36 | 35 |
| West Block. | 63 | 61 |
| Langevin Block. | 48 | 48 |
| Post Office | 20 | 20 |
| Thistle Block. | 2 | 2 |
| Ottawa Electric Company. | 1 | 1 |
| Mint. | 16 | .. |
| Archives. | 7 | .. |
| Observatory. | 28 | 28 |
| | <hr/> | <hr/> |
| | 270 | 241 |
| Program clock. | 1 | 1 |
| Seconds dials. | 3 | 2 |
| Tower clocks. | 2 | 2 |
| | <hr/> | <hr/> |
| Total electrically driven clocks. | 276 | 246 |
| Secondary master clocks. | 8 | 7 |
| Primary clocks. | 4 | 4 |
| | <hr/> | <hr/> |
| Total. | 288 | 257 |

TRANSIT OBSERVATIONS.

Observations with the portable transits were taken on 142 nights, involving 281 determinations of clock error, as well as some observations for other purposes; on a number of nights two, and sometimes three, observers worked simultaneously, for determination of personal equation.

The relative personal equation of the Ottawa observers was in addition determined from the clock-curve, which was regular. The method of observation for clock-error was that described in last year's report, Appendix No. 3; the increase in accuracy over previous years was in the neighbourhood of 50 per cent. There were 156 exchanges for longitude, occupying 116 nights; exchanges were had irrespective of the weather at Ottawa, the clock error being when necessary interpolated from adjacent nights. An analysis was made of the rate of the Sidereal Standard as shown by the observations; the probable variation of daily rate appears to be between .01 sec. and .02 sec. per day; the advantage of having a completely uniform temperature is markedly shown. An approximate investigation was made, by observations suited to the purpose, of the causes underlying personal equation in micrometer observations. Mr. Stewart found in his own case a tendency to set the movable wire always to the same side (the left) of the star, by a quantity in the neighbourhood of a second of arc, depending on the magnitude of the star; north stars at upper culmination would thus be observed too soon, others too late. This affects the observed clock-error, and more markedly the azimuth. It was found that this would approximately explain the difference in personal equation of two of the observers, but not completely that of the third.

MERIDIAN CIRCLE.

The piers in the meridian circle room and the transit room have been rebuilt, their bases being sunk deeper into the earth and a system of drainage into a specially prepared cistern being installed, the cistern being pumped out from time to time. During wet periods there has proved to be a great accumulation of water in the cistern;

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though the latter holds in the neighbourhood of 1,200 gallons it has on a number of occasions been filled to overflowing in a single night, apparently by surface water entering under the foundation walls of the building. This is very undesirable, as in that case the water becomes backed up around the footings of the piers. The only remedy would seem to be a proper drain surrounding the outside walls to carry off the surface water.

Provision has been made in the collimator piers for underground lenses to serve as permanent marks, over which may be adjusted the long-focus collimating lenses for the azimuth marks; pits have also been provided to allow access to the underground marks. The positions for the azimuth marks have been accurately determined and marked.

The mechanism for opening the roof shutters has been installed and works satisfactorily; the iron wall shutters have been replaced by wooden ones; wire frames have been made for the louvres in the walls to exclude snow, and have been in place during the past winter; the piers have been encased in felt and wood, with an air-space, to avoid sudden changes in temperature; an extension was made to the main instrument pier to provide for observations by reflection.

The meridian circle itself was in the beginning very unsatisfactory in almost all respects. When the graduated circles were received from the makers after having been repaired it was found that owing to irregularities in the bearings on axis and circles, the plane of the graduations was not perpendicular to the axis, nor was the distance from graduations to end of axis the same for both circles. While the adjustment of these errors was in progress it was found that the pivots were soft; it was therefore necessary to turn down the pivots and fasten upon them hardened steel bushings. Owing to the lack of lathes and grinders of the size requisite to handle the axis this proved a most arduous undertaking, but has at length been successfully accomplished. In this connection I wish to express my appreciation of the very great kindness of Mr. A. H. W. Cleave, of the Royal Mint, who was good enough to offer us the use of his workshop and even to have alterations made in his machines which made it possible to handle the work. Had it not been for his kindness the work could hardly have been done in Canada. There is still a great deal of work to be done on the instrument before it will be in a condition to do effective work. The counterpoises are unsatisfactory, and will require to be replaced by new ones; the bearings of the vertical circle require to be scraped and polished; alterations are necessary in the micrometers of the circle microscopes; the double spider lines in right ascension and declination micrometers and circle microscopes are at unsuitable and varying distances; in addition there is a multitude of small details that require alterations. When these have all been completed, however, the instrument will probably do efficient work. It is hoped that it may be ready for systematic work in both right ascension and declination by the beginning of the year.

For further details reference may be had to Mr. R. M. Stewart's report, in Appendix No. 3.

WORK OF THE ASTROPHYSICAL DIVISION.

The principal work in this division has been observation by the spectroscope of the radial velocities of spectroscopic binaries for the determination of the elements of their orbits. Five orbits have been thus determined: η Bootis, θ Aquilæ, α Coronæ Borealis, ϵ Herculis, β Orionis. In only the first of these have the observations been well satisfied by a velocity curve due to simple elliptic orbits. In two of the others irregularities show which are explained fairly well on the hypothesis of the presence of a third body. Four stars with early type spectra δ Herculis, γ Aquarii, ι Andromedæ, and ξ Persei, have been examined and their velocities found to be variable, but not enough observations have been made to determine the law of variation. Twelve other binary systems are under observation.

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Considerable time has been spent in testing and adjusting the instruments and in experimenting on the best methods of observation. Mr. Plaskett investigated the fields given by different types of camera objectives for spectrographs, and the effect of increased slit width upon the accuracy of radial velocity work. Dr. DeLury examined the errors of the plane grating of the spectrograph of the coelostat. Mr. Motherwell investigated the aberration of the eight-inch doublet of the stellar camera, and proved that the halos which the lens gives around the images of stars are due to spherical aberration, which may be corrected by slight refiguring of the lens.

Other work in this division has been micrometric measurements of double stars, comet photographs, observations of occultations of stars, and solar photography. This work as well as all the other astronomical work has greatly suffered from the dense smoke from forest fires which prevailed during a great part of last summer.

Fuller details of this work will be found in Mr. Plaskett's report, Appendix No. 2.

DIVISION OF GEOPHYSICS.

Continuous records have been obtained by the Bosch seismograph of earth movements. Some forty-nine earthquakes were recorded during the twelve months from April 1, 1908, to April 1, 1909, including five of some severity. Ordinarily the record of an earthquake shows that waves of three kinds are received. These are called the first preliminary, the second preliminary, and the long waves. They are distinguished from one another on the seismograph sheet by differences in form and amplitude, and the times of first arrival of the waves of each type may be measured off from the sheet very nearly.

It is supposed that the three waves have their origin at the same instant of time at the centre of disturbance, and that the difference in time of arrival is due to a difference in the mode of transmission through the earth's crust, whether by longitudinal or transverse vibrations through the depths of the earth, or near the surface, and that corresponding to the different modes or paths of transmission are different but definite velocities.

These velocities have been found by many observations within pretty close limits. Hence the difference of time between the first arrival of the different waves gives immediately the distance of the origin of disturbance. The actual position of the origin may often be determined by drawing a circle on a terrestrial globe with centre at the place of observation and radius equal to the distance of the origin. Where this circle passes through a region of known seismic activity, the probable origin of the disturbance may be placed.

Besides the records of earthquakes, numerous minor tremors, called microseisms, have been registered. An account of these, with an inquiry into their probable causes will be found in the report of Dr. Klotz, which forms Appendix No. 1 to this report.

Dr. Klotz concludes that the microseismic vibrations of the pendulums of the seismograph are closely connected with the gradients of barometric pressure, and that their amplitudes increase with the steepness of the gradient.

Microseisms are not due to the dynamical effect of the movement across the continent of areas of high or low pressure, nor to the direct dynamical effect of winds.

Microseisms registered at Ottawa almost invariably co-exist with 'lows' over the Gulf of St. Lawrence with steep gradients over the St. Lawrence valley.

They arise from movements of large areas of the earth's crust, and are related to the geological structure by which probably their period is determined.

The meteorological conditions on which they appear to depend are not local; the variations of local barometric pressure shown by the micro-barograph cause local bendings of the earth's crust which are exhibited on the seismograms by deflection of the zero of the instrument, but the irregularities thus caused are easily distinguished by their irregularity from the real microseisms.

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It has been suggested that the fact that the period of most of the microseisms nearly agrees with that of the pendulums, indicates that the record is due to air currents within the instrument or to other instrumental cause. This explanation, however, cannot stand, in view of the evidence adduced by Dr. Klotz, of co-incident occurrence with the 'lows' on the eastern coast.

AUXILIARY BUILDINGS OF THE OBSERVATORY.

During the past year the coelostat house has been completed, and the coelostat installed, with its spectrograph. As stated above a careful examination has been made of the plane grating of this instrument, by which certain defects have been indicated. The making of this necessary examination has delayed the making of the observations on the sun which were contemplated.

The building for the standardizing of tapes and other measures of length has been completed, but the apparatus for making comparisons has not yet been installed. Means will be provided for tests of measures up to 50 metres in length.

Ground was broken for the residence of the Chief Astronomer about the middle of March last. This building will stand a short distance to the east of the Observatory.

Work was begun last summer on the grading of the grounds surrounding the Observatory, a much needed improvement. Owing to the excessive dryness of the latter part of the summer it was not thought advisable to do any sodding, which has been postponed until this season.

FIELD ASTRONOMICAL WORK.

Latitudes and longitudes were determined at twenty-seven stations during the season of 1908.

Two stations on the southern boundary of British Columbia, one near the southern boundary of Manitoba in the neighbourhood of Lake of the Woods, and three on the Ontario-Minnesota border, were observed for purposes of the boundary surveys. The other points were observed for geographical purposes, and comprise three points in Ontario, eight in Quebec, eight in New Brunswick, and two in Nova Scotia. The longitudes of the two most westerly stations were determined by telegraphic signals from Seattle, a point of known longitude; that of the others by signals from this Observatory.

Observations of the magnetic elements were made at seventeen points in British Columbia and at Winnipeg, Ottawa and Agincourt. The instruments used were the Tesdorpf magnetometer and the Dover dip-circle.

INTERNATIONAL BOUNDARY SURVEYS.

On June 3, 1908, a treaty between His Majesty and the United States was ratified, which provides for the survey of the whole of the boundary line from the Atlantic to the Pacific.

The treaty divides the boundary line into eight sections, and prescribes the manner in which the survey of each section shall be carried out, and placed the carrying out of the work, except as regards the fourth section, in the hands of two commissioners who shall be 'expert geographers or surveyors.'

The several sections are as follows:—

1. In Passamaquoddy bay, from the open waters of the Bay of Fundy to the mouth of St. Croix river (at Joe's Point near St. Andrews, N.B.).

By the treaty of 1783, the boundaries of the United States were defined as beginning at the mouth of St. Croix river and ascending that river to its source. Then the description proceeds with the northeastern, northern, western and southern boundaries of the United States, terminating on the Atlantic ocean at the northern

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boundary of Florida. The territory of the United States was also to include 'all the islands within twenty leagues of the coast except such as have heretofore belonged to His Majesty's province of Nova Scotia.' ('Nova Scotia' then included the present province of New Brunswick.)

Soon afterwards question arose as to which river was the St. Croix, mentioned in the treaty; it appears that three or more rivers bore that name. Commissioners were appointed under a special provision by treaty (1794) to decide which river was intended and to determine its mouth and its source.

The Commissioners in due course reported (1798) their decision identifying the St. Croix river of the treaty with the river which now bears the name, and placed its mouth opposite Joe's Point, the point at the southwestern extremity of St Andrews peninsula, opposite to the town of Robbinston, in Maine.

South and east of this point lies Passamaquoddy bay, being the western part of the Bay of Fundy, and including an extensive archipelago.

It will be observed that the decision of the Commissioners, placing the mouth of St. Croix river at Joe's Point, left the jurisdiction over the islands of this archipelago, which are within twenty leagues of the United States shores, to be determined by the fact whether they had previously belonged to the United States or to Nova Scotia.

Under the fourth article of the treaty of Ghent, 1814, Commissioners were appointed to determine to which of the High Contracting Parties the several islands belonged. These Commissioners rendered their decision in 1817 to the effect that Moose, Dudley and Frederick islands belonged to the United States, and that all the other islands in Passamaquoddy bay, and the island of Grand Manan, in the Bay of Fundy, belonged to His Britannic Majesty. This decision, however, did not determine the locality of the boundary line in the narrow waters between Campobello island and the islands allotted to the United States, and subsequently difficulties arose in regard both to smuggling and to fishery rights.

It was not until 1892 that provision was made by treaty for the determination of the boundary line in these waters, and commissioners were appointed to determine and mark the line.

This the Commissioners did in part but not wholly, since they failed to agree as regards the ownership of a certain island and of certain fishing grounds.

By the treaty of 1908, provision was made for the preparation on the behalf of each government of a 'case' to be submitted to the other, and in the event of their not arriving at an agreement within one year of the date of ratification of the treaty, for a reference of the question to arbitration. The cases of the two governments were duly presented on December 3 last, six months after ratification of the treaty.

These negotiations, or the arbitration which will result, if they do not result in an agreement, have reference only to the two specific points on which the Commissioners of 1892 differed. Their marking of other parts of the line is confirmed by the treaty. The present Commissioners are to renew the marks when necessary, and to lay out the remainder of the line when a decision of the disputed questions has been arrived at. Pending such decision no work has yet been done on this section.

2. The second section of the line is that along St. Croix river from its mouth to its source.

As already stated the Commissioners of 1798 determined the source of this river as well as its mouth. This was sufficient to obviate disputes involving any large extent of territory, and no serious question is known ever to have risen. For this reason doubtless no survey of the river as an international boundary has been made, or indeed provided for, by any previous treaty. In its course the river expands into several large lakes in which as well as in the river itself islands exist, which may become of importance in the future. The treaty provides that the boundary line shall follow the thalweg, or middle of the main channel as naturally existing, except where such would conflict with the recognized national character of an island. The boundary line is to

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be marked where possible by permanent monuments, and is to be shown by the Commissioners on accurate modern charts. Like provisions apply to all the sections of the boundary line.

It is proposed to send out two survey parties, an American and a Canadian party this summer to make the preliminary survey necessary for the setting out of the permanent reference marks. They will operate in the navigable part of the river below the international bridge connecting St. Stephen and Calais.

3. The third section extends from the source of the St. Croix to the St. Lawrence river. An approximate description of this section of the boundary line is: along the meridian of the source of St. Croix river to St. John river, up the latter and one of its branches, St. Francis river, to a certain point; in a straight line to the southwest branch of St. John river; up the last to its source in the highlands (of the St. Lawrence); along the highlands to the source of Hall's stream (a branch of Connecticut river); down the last to the 45th parallel; and along the 45th parallel to the St. Lawrence.

By the treaty of 1783, the boundary line was to follow the due north line from the source of St. Croix river to the highlands dividing the waters flowing into the St. Lawrence from those flowing into the Atlantic ocean, and thence to follow the highlands to the source of Connecticut river; and follow the river to the 45th parallel, and the parallel as far as the St. Lawrence.

Dispute arising as to the location of these highlands, this section of the boundary line remained undetermined for many years, the question about the year 1840 assuming a very serious phase, though more than one attempt had previously been made to settle it. By the treaty of 1842 the matter was finally disposed of, the definition adopted for the boundary, being a compromise between widely differing claims. The line was surveyed and marked with cast-iron monuments in the years 1843 to 1846, by a joint Commission.

For brevity in the above description of the boundary line, I have spoken of the meridian line of the source of the St. Croix and of the 45th parallel. The boundary line does not accurately follow these astronomical lines, but follows the lines of old surveys, originally intended to coincide with them, but which show in places very large deviations from them. The perpetuating in this manner of the errors of the old surveys was dictated by reasons of convenience arising out of the fact that in many instances the country had been settled on either side up to the old survey, and the lands were in private hands.

As a result of complaints which had from time to time been received, that some of the original monuments had been destroyed and that there was difficulty in places in finding the line, in 1890 an inspection, jointly with representatives of the state of New York was made of the line from Richelieu river to the St. Lawrence. This inspection indicated that it was necessary to renew the original monuments, as well as to place new ones where the line had been in the first instance insufficiently marked.

Nothing, however, was done until 1902, when an agreement for co-operation in the work of renewal was made with the government of the state of New York with the concurrence of the Washington government and a joint re-survey of the line was made, and new monuments of granite were erected.

In 1906 an agreement was made with the United States government for a joint re-survey of the rest of the line from Richelieu river to the St. Croix, and the work has since been actively prosecuted. The re-survey and renewal of monuments has been completed from Richelieu river to Hall's stream (covering the northern boundary of the state of Vermont) and along the meridian of the St. Croix river to the St. John. This has been done by a joint survey party representing both governments. The work so done will of course be available for the use of the Commissioners appointed under the new treaty.

It is proposed this year to proceed with the survey along the River St. John.

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4. The fourth section covers the River St. Lawrence, the Great Lakes and their connecting waters, from the intersection of the 45th parallel by the River St. Lawrence to the mouth of Pigeon river in Lake Superior.

A general and rather vague description of this part of the line was contained in the treaty of 1783. The sixth article of the treaty of Ghent, 1814, provided for the appointment of Commissioners to determine the actual course of the line through the rivers and lakes, from the initial point in the St. Lawrence as far as the water communication between Lake Huron and Lake Superior. The seventh article of the treaty provided that the same Commissioners should determine the line from the said water communication to the North West Angle of the Lake of the Woods.

The Commissioners made the necessary surveys and laid down the line on their maps, reporting in 1822 their agreement so far as their work under the sixth article of the treaty was concerned. They, however, were unable to come to a full agreement under the seventh article, and that part of the line remained undetermined until settled by the treaty of 1842.

Owing to the imperfections of the maps upon which the Commissioners under the treaty of Ghent drew their line, difficulty is found in accurately transferring it to modern charts. The present treaty provides for the ascertainment and accurate re-establishment of the line, for the laying of it down on modern charts, and for the marking so far as practicable of the course of the line by buoys, monuments and range marks.

The carrying out of these provisions with respect to the fourth section of the boundary line is placed in the hands of the International Waterways Commission, which is composed of three Commissioners on the part of the Dominion of Canada and three Commissioners on the part of the United States.

5. The fifth section extends from the mouth of Pigeon river, up that river and through various lakes and rivers to the North West Angle of the Lake of the Woods.

The North West Angle of the Lake of the Woods was one of the governing points in the description of the boundaries of the United States in the treaty of 1783. Its location was ascertained without difficulty, but from the want of good maps when the treaty of 1783 was framed the line between the Lake of the Woods and Lake Superior was so vaguely defined as to leave room for widely different interpretations. Thus one contention was that the boundary line should ascend the St. Louis river at the head of Lake Superior, where Duluth now stands; another, that it should ascend the Kaministiquia. The Commissioners under the treaty of Ghent narrowed the question down to a choice between two water routes, both leading from Pigeon river to Rainy lake, and thence by Rainy river to Lake of the Woods. These two routes diverged a short distance up Pigeon river, passing one north and the other south of a considerable area almost surrounded by a series of lakes and rivers, now known as Hunter's island. By the treaty of 1842 the southern route was adopted.

No survey of the international boundary has been made along this section of the line. The Commissioners under the treaty of Ghent prepared maps to illustrate their report, but their surveys were imperfect.

The Commissioners under the present treaty having the duty of exhibiting the boundary line on modern charts will have to make a topographical survey over the whole distance.

6. From the North West Angle of the Lake of the Woods to the Rocky Mountains.

The treaty of 1783 described the northern boundary of the United States after reaching the North West Angle as proceeding thence west along the 49th parallel of north latitude to the Mississippi river.

It was afterwards ascertained, however, that the North West Angle lay about twenty-five miles north of the 49th parallel, and that the Mississippi river did not extend so far north as the parallel by a considerably greater distance.

The treaty of 1818 provided that the boundary line should follow the 49th parallel west to the Rocky Mountains. To provide for the difficulty as to the latitude of the North West Angle, it was agreed that the boundary line should be drawn due south from the angle of the lake to the 49th parallel. Thus occurred the peculiar 'jog' which the maps show in the boundary line at Lake of the Woods.

An interesting point in this connection is that the Commissioners who surveyed the meridian south from the North West Angle in 1872 found that their line starting from the old monument marking the North West Angle crossed the line of boundary which had been drawn by the Commissioners under the treaty of Ghent along the inlet of the lake at the head of which the monument stands.

This meridian line and the 49th parallel west as far as the Rocky Mountains were surveyed by a joint Commission in the years 1872 to 1874. The line was marked by iron posts one mile apart so far as the old boundary of the province of Manitoba extended (from longitude 96° to longitude 99°). On the remainder of the line the monuments were farther apart, averaging about three miles, and consisted of large mounds of earth or stones.

The re-survey of the line has the purpose of re-locating and repairing lost or damaged monuments, and establishing additional monuments wherever necessary to meet the requirements of modern conditions.

The doing of this was provided for in an administrative agreement between the governments, entered into in 1902. This agreement provided for a survey of the whole line from Lake Superior to the Gulf of Georgia, on the Pacific coast, but the completion of the portion west of the Rocky Mountains being more immediately pressing, operations were begun at that end, and the section east of the Rocky Mountains was not reached until last year. A Canadian party under Mr. J. J. McArthur began operations at Coutts, Alberta, which lies about one hundred miles east of the Rocky Mountains. The operations of the survey during the season covered one hundred miles east from Coutts, the section west of that place being left to an American party, under an agreement between the Commissioners by which the line was divided into alternate sections of one hundred miles.

7. From the Rocky Mountains to the Gulf of Georgia.

By the treaty of 1846, the boundary line here also lies on the 49th parallel. It was surveyed and monumented by a joint Commission in the years 1859 to 1863. The monuments generally consisted of mounds of stones, though along a certain part of the line cast-iron monuments were placed. Owing to the exceedingly mountainous character of the country the survey was not a continuous one; the position of the parallel was determined by astronomical observation in some of the principal valleys, and the line was cut out east and west from the astronomical stations as far as possible in the circumstances.

The survey made under the agreement of 1902 is continuous, from the summit of the mountains to Point Roberts in the Gulf of Georgia. Monuments of alluminium bronze, set in concrete bases, have been placed at average distances of two miles along the whole length of the line, and a wide vista has been cut through the forest from monument to monument. The field work was completed in 1907, with the exception of a short piece of triangulation in the Cascade Mountains, which was finished last year. The plans and other records of the survey have yet to be put into final shape for publication.

8. The eighth section is the water boundary from the 49th parallel to the Pacific ocean.

By the treaty of 1846 the boundary line was to follow the 49th parallel to the middle of the strait between Vancouver island and the mainland, and of the strait of Fuca to the Pacific ocean.

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East of the southern extremity of Vancouver island and lying between it and the mainland lies an archipelago of considerable extent. Not many years after the treaty of 1846 the question arose to which country these islands belonged.

The principal island in the group is the island of San Juan, and the question which arose is commonly referred to as the San Juan question. The group is separated from Vancouver island and the islands adjacent thereto by Haro strait, and is separated from the Washington shore and its adjacent islands by Rosario strait. Both countries claimed ownership of the group of islands between these straits and for several years there was joint occupation of San Juan island by military forces.

By the treaty of Washington, 1871, it was agreed to refer the question to the decision of the Emperor of Germany, who decided in favour of the United States, that the boundary line should follow Haro strait.

In 1873 at a conference held at Washington by representatives of both countries an agreement was reached as to the actual course of the line, in accordance with the Emperor's decision, and the boundary line was defined by a line drawn upon a chart, accompanied by a written description.

The present treaty in providing for the survey of this line follows accurately the wording of the protocol of the conference of 1873, excepting at one point only, where a short curved line is replaced by a straight line.

It is proposed during the present season to send two survey parties to make the necessary surveys for the placing of reference monuments to perpetuate the points named in the treaty.

Mr. O. H. Tittmann, Superintendent of the United States Coast and Geodetic Survey, and the writer were appointed in June last commissioners, representing respectively the United States and His Majesty, for the carrying out of this treaty (excepting as regards the fourth section of the line).

Canada-Alaska Boundary Line

This boundary is in two sections, the most northerly following the 141st meridian of west longitude from a point near the summit of Mt. St. Elias to the Arctic ocean, the other starting from Cape Muzon on Prince of Wales island in about latitude $54^{\circ} 40'$, crossing the sea to the entrance of Portland channel, ascending the channel to a certain point, and then following certain mountains.

This boundary was first defined by the treaty of 1825, between Great Britain and Russia. The treaty described the line from its point of commencement, the southernmost point of Prince of Wales island, up Portland canal, and thence in a direction generally parallel to the coast to the 141st meridian of longitude west from Greenwich; thence along that meridian to the Arctic ocean. This definition of the boundary was of course not affected by the transfer of Alaska to the United States in 1867.

No demarcation had been attempted during the Russian occupation, but a few years after the transfer attention became directed to the boundary question. It was seen that the interpretation of the treaty as regards the southern part of the boundary, from Prince of Wales island to the 141st meridian, presented great difficulties, while the description of the remaining portion, following a definite astronomical line, the 141st meridian, was clear and unambiguous, and has never been the subject of controversy.

Hence in subsequent discussions the boundary line has been divided into two parts, which have been dealt with separately.

It is not my intention here to go into detail concerning the points of the controversy over the line from Prince of Wales to the 141st meridian. In 1892 a treaty was entered into between Great Britain and the United States, the first article of which provided for the appointment of commissioners to make a survey of the region

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adjacent to the line with a view to the ascertainment of the facts and data necessary for the permanent delimitation of the line in accordance with the spirit and intent of the then existing treaties.

The Commissioners made extensive topographical surveys of the mountains adjacent to the coast, and rendered a joint report to the two governments on December 31, 1895.

Although the treaty provided for the consideration of the boundary question, as soon as the report of the Commissioners had been received, the matter was not taken up until three years later, when it was discussed by the Joint High Commission, but without any action being determined upon.

In 1903, by treaty, the matter was referred in the form of five questions to a tribunal of six jurists, who held their sittings in London in September and October, 1903.

By their decision the line was to be drawn from Cape Muzon, on Prince of Wales island, in a straight line to a certain point off the mouth of Portland canal; up the canal to a certain point; then following certain mountain summits (which they marked out on the maps prepared by the survey made under the treaty of 1892) to Mt. St. Elias, which is near the 141st meridian.

The series of mountain summits selected by the tribunal was incomplete, in that between a certain summit north of Frederick sound and another north of Taku inlet a gap was left, some 120 miles in extent. In this gap the tribunal found the available topographical information not sufficiently complete to enable them to decide which were the mountains referred to in the treaty of 1825, and the line as regards that portion was left undetermined.

In the following year a conference between the Commissioners charged with the duty of the demarcation was held, at which a recommendation was made as to the course which the line should follow across the gap, and in March, 1905, this recommendation was formally approved by both governments.

By this agreement the line follows southward from the peak north of Taku inlet, from summit to summit of seven intervisible mountains, till a point near Whiting river is reached. Another peak was selected near the southern end of the gap. These eight peaks lie nearly in a straight line between the two terminal peaks of the Award. Between the seventh and eighth of them a gap remains about 50 miles in length in which the agreement leaves the selection of peaks in the hands of the Commissioners, after necessary surveys are made, the peaks selected to be intervisible and none of them more than 2,500 metres distant from the straight line joining the terminal peaks.

Survey of the Boundary of the Coast Strip of Alaska.

The demarcation of the Award line was begun in 1904 and has been continued since as rapidly as possible.

The work of the season of 1908 comprised the marking of the line at Alsek river, on the southern branch of the Iskut river (a tributary of the Stikine) and on the Unuk river and its tributaries, besides the topographical survey necessary for the carrying out of the agreement of 1905.

The Iskut work was carried on by Mr. J. D. Craig, D.L.S., and that of the topographical survey by Mr. W. F. Ratz, D.L.S., while Mr. White-Fraser, D.T.S., and Mr. F. H. Mackie, D.L.S., worked on the Alsek and Unuk rivers respectively, in conjunction with American parties.

The topographical survey of the region between the peak above referred to near Whiting river and the mountains north of Frederick sound was begun by Mr Ratz in 1907, and completed by him last year, so that the Commissioners have been able to

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make a selection of summits which accord with the conditions of the agreement of 1905, and it is hoped that the demarcation of this part of the line will be completed during the coming summer.

When this has been done little of the boundary of the coast strip of Alaska will be left for demarcation except a fifty-mile stretch near Mt. St. Elias and two or three uncompleted portions of a few miles each.

I regret to have to record the death of Mr. Ratz which occurred in Ottawa on February 6. Mr. Ratz had been employed on the Alaska survey since 1905. He carried out the demarcation of the line at Salmon river (Chilkat district), and in part between Taku inlet and Whiting river. During the last two years he was engaged, as already stated, on the topographical survey between Whiting and Stikine rivers, not the least difficult section of a very difficult survey. His success in carrying this to completion in a relatively short time is a testimony of his capability as a surveyor as well as to his personal energy. His death, at the early age of 25, is a serious loss to the profession and to the public service.

Survey of the 141st Meridian.

This survey and demarcation is carried on in pursuance of the treaty of 1906.

This treaty does not alter in any way the boundary line as defined by the treaty of 1825, but provides for the manner of making the survey and the demarcation merely.

Operations were begun in 1906 by ascertaining the position of the meridian at the crossing of the Yukon river by astronomical observations for longitude, using the telegraph for comparison of time.

The survey of the line south from the Yukon crossing was begun in 1907, and in 1908 continued southward to a point south of White river, a distance from the Yukon crossing of 225 miles. The placing of the permanent monuments on the line made good progress, as also the triangulation and topographical survey which is being made along the line.

Mr. A. J. Brabazon, D.L.S., was in charge of the Canadian parties engaged in this work.

THE GEODETIC SURVEY OF CANADA.

The work accomplished by the Geodetic Survey staff during the season of 1908 is briefly as follows:—

Two observing parties, measuring horizontal angles, were in the field during the whole season, but on account of the prevalence of dense smoke very little work was accomplished. The district covered lies between Brockville and Toronto.

Reconnaissance surveys were conducted in the maritime provinces, in the province of Quebec, in western Ontario and along the international boundary west of Lake Superior. This latter reconnaissance was for the purpose of making a primary triangulation to control the survey of the international boundary along Pigeon river. The reconnaissance in the province of Quebec, which embraced all of that part of the province lying southeast of the St. Lawrence river from Montreal to a point some thirty miles below the city of Quebec, and also one row of triangulation stations to the northwest of the St. Lawrence river a sufficient distance back therefrom to secure high enough points to control the country to the southeast was most gratifying in its results; it was successful in securing an excellent system of quadrilaterals and large five and six sided figures with central points.

The work of signal building was continued west of Toronto as far as Woodstock or thereabouts. In the maritime provinces reconnaissance has been satisfactory. The stations for a triangulation extend from Chamcook mountain in the southwest corner

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61 New Brunswick, to the northerly extremity of Cape Breton island, embracing a district about fifty miles wide between those points, including the easterly portion of Prince Edward island. Chamecock mountain is one of the primary triangulation stations of the United States Coast and Geodetic Survey and in conjunction with Prescott Rock—another primary station of the same survey—direct connection is made with the Geodetic Survey of the United States.

In 1908 two Geodetic levelling parties were employed and a line of levels was carried from Coteau Junction—thirty-eight miles southwest of Montreal—to Fort Erie via Hamilton, and also from Hamilton to London. The computations are now in progress and are sufficiently advanced to show that the results are of a high order of precision. The work has been carried on by a double line of levels running forward and backward directions, the forward and backward levelling being independent of each other in every respect, and when possible, performed under different atmospheric conditions. The standard of accuracy adopted requires that the backward levelling shall correspond with the forward levelling within $0.017 \sqrt{M}$, 'M' being the distance in miles covered by the section. The dense smoke, so prevalent during the season of 1908 and which interfered so materially with the trigonometrical work, was found to be an assistance in precise levelling, inasmuch as the usual steadiness of the atmosphere—no doubt caused by smoke—made the observing of the graduations on the levelling rod much easier than in former seasons.

Consequent upon a discussion in parliament, in which was apparent a concurrence of opinion that an accurate survey of the better settled parts of Canada would be of practical benefit, the government, by order in council of April 20 last, formally instituted the 'Geodetic Survey of Canada,' and appointed the writer superintendent.

The following appendices are attached to this report:—

Appendix 1.—Report by Otto Klotz, LL.D., on seismological and magnetic work.

Appendix 2.—Report by J. S. Plaskett, B.A., on the astrophysical work.

Appendix 3.—Report by R. M. Stewart, M.A., on meridian work and time service.

Appendix 4.—Report on observations for latitude and longitude by J. Macara.

I have the honour to be, sir,

Your obedient servant,

W. F. KING,

Chief Astronomer and Boundary Commissioner.

APPENDIX 1.

REPORT OF THE CHIEF ASTRONOMER, 1909.

SEISMOLOGY, TERRESTRIAL MAGNETISM AND
GRAVITY

BY

OTTO KLOTZ, LL.D.

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APPENDIX I.

SEISMOLOGY, TERRESTRIAL MAGNETISM AND GRAVITY, BY OTTO KLOTZ, LL.D.

OTTAWA, ONT., July 1, 1909.

W. F. KING, LL.D., C.M.G.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR,—I have the honour to make the following report of the work carried out under my charge, and which is classified under the three headings—Seismology, Terrestrial Magnetism and Gravity.

SEISMOLOGY.

Instruments.—The instruments which are in service are: two Bosch photographic seismographs, described in the report for 1906; a Callendar electric recorder; a Negretti and Zambra barograph; a Shaw-Dines micro-barograph, besides wet and dry bulb thermometers.

The Callendar electric recorder is from the Cambridge Scientific Instrument Company, England. It was installed in August 10, 1908, and has given satisfaction. It records the outside temperature. It is similar to the one used in connection with our standard sidereal Riefler clock for temperature control. In the report for 1907 Mr. R. M. Stewart gives an illustration of the recorder, together with a detailed description, so it is unnecessary to describe the other one. It may be mentioned, however, that the extreme possible range of outside temperature is confined within the range of the galvanometer wire along which the sliding contact balances the resistance of the platinum wire thermometer, wound on a mica frame. The thermometer is housed in a louvered shelter 2 feet 6 inches by 1 foot 8 inches and 2 feet 6 inches high with slanting double top, the whole being painted white; it is mounted on four posts and the bottom is 4 feet above the ground in an open space with free circulation of air. It is 46 feet from the northwest corner of the transit house of the observatory. The lead-covered double leads are led from the thermometer in an iron 3-inch pipe under ground, then through the wall of the Observatory and finally into my room to the recorder. The range of resistance on the galvanometer wire and covering the sheet which is daily renewed, is equivalent to 100° , that is, the readings extend from -50°C. to $+50^{\circ}\text{C.}$ or from -58°F. to $+122^{\circ}\text{F.}$, and this is represented in linear measure on the sheet by 20 cm., so that 1°C. is equivalent to 2mm. The temperature records are very satisfactory, and the rapid oscillations of temperature on bright cloudless days is very marked. These fluctuations amount to several degrees within a few minutes, showing that the atmosphere is far from being homogeneous as far as temperature is concerned, but instead is permeated by thermal and density 'schlieren,' continuously shifting. The scale of the bridge-wire was determined by readings of several standard mercurial thermometers placed within the thermometer shelter.

Last March another platinum wire thermometer was installed; it is in the well at the bottom of the south collimator pier of the meridian circle. The leads of this

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thermometer are led to a special switch beside the recorder, and every morning before taking off the sheet a reading is taken of this latter thermometer, which is subject, of course, to a very slow change of temperature.

Of the aneroid barograph with its weekly recording sheet nothing further need be said. Beside it hangs the Greene standard mercurial barometer and by which the readings of the former are checked.

In connection with the study of the seismograms, especially of the microseisms and other records, such as movements of the position of the pendulum zero not attributable to earthquakes, a Shaw-Dines micro-barograph was installed last July (1908), also a Richard Frères statescope. Although the latter works very well, its time-scale is too large (one revolution of the cylinder in less than an hour) for continuous use. The former is 'an apparatus designed to magnify and record the minor and sudden fluctuations of the atmosphere as opposed to the general atmospheric surges. It records the small variations on a scale magnified twenty fold, the general surges being practically obliterated through the operation of a small leak. It thus records comparatively rapid oscillations, and no others. The instrument consists of a small, closed vessel containing air, which communicates with a mahogany box containing mercury, on the surface of which floats, mouth downwards, a light hollow cylindrical bell. The air is enclosed in a large japanned metal chamber, the space between the two being filled with a non-conducting material. The movements of the bell are transmitted to the chart by means of a delicate system of leverage. The chart is wound round a drum actuated by clock-work, and making one revolution in twenty-four hours.'

This instrument (micro-barograph) has given efficient service for the purpose for which it was desired, viz., in the first place to give a record of very rapid barometric fluctuations with the accompanying gusty winds, and secondly to enable one to make a comparison of such record with the seismogram to determine the relationship, if any, between the micro-barogram and seismogram. This has now been clearly and unequivocally established by simple ocular demonstrations. Whenever a closely serrated line with amplitudes of a sixteenth to quarter of an inch (about the maximum for very rapid oscillations) is found on the micro-barogram, the seismogram will show for the same time invariably an irregular record, not microseisms, which appear as a combination of tilting and horizontal movements, probably vertical movements too. They can never be mistaken for any phase of earthquake effects nor for microseisms, about which more will be said hereafter. The service of this instrument has been wholly confined to interpretation of some of the disturbances recorded by the seismograph and not for other meteorological purposes, as that is outside of our field.

The electric light 16 c.p., 104 v., continues to serve for the seismograph, and is efficient although slightly reduced in brightness when the machinery using the motor, and the lights of the observatory are on. A 'detector' was installed in my room, on the wall opposite to my desk. The object is to show when, by accident, the filament of the seismograph lamp should break, or otherwise the light circuit be interrupted. This is effected by having two small 1-candle power lamps in series, with the main lamp in the basement, and being themselves in parallel. The idea of having the two small lamps in parallel is that if one of them should give out, the circuit would not be interrupted, but would show by the other small lamp burning much brighter. The scheme works very well.

In last year's report I spoke of the trouble that some of the electric lamps, necessarily with single filament, gave by the vibrations set up in the filament and produced by the electric current alone. This has been nearly eliminated by the use of new lamps with shorter filaments. Occasionally spots of a widened line are shown on the seismogram when the filament has oscillated for a few seconds. It is a rather peculiar phenomenon and was discussed in detail last year.

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The two horizontal pendulums have remained in their respective positions N.-S. and E.-W. during the year. The steel point of the N.-S. pendulum bearing against the lower support was found to have become somewhat blunted, so it was replaced by a spare point supplied by Bosch when the instrument was purchased. The effect of this was well shown in the record of microseisms whose amplitude although always small was distinctly increased by the decrease of friction at the point of lower support. For this same pendulum, as noted last year, the air-damping had been replaced by oil-damping, in the belief that the oil would be very much more efficient for the purpose of damping. Neither the damping by the oil nor the surface tension manifested themselves as conspicuously as anticipated. The experimental test was made with an immersion of 3mm. by the aluminum vane of the aluminum rod which extends from the 'bob,' or mass. The damping co-efficient was practically the same as with the air damping. The oil used was ordinary bicycle oil with some clock oil.

As in previous years a record has been kept of the hygrometric condition immediately without and within the seismograph room. The humidity although subject to small oscillations is in general dependent upon the season and the artificial heating of the building during the colder months. The least humidity is during the winter, and the greatest during the summer, ranging from an average of 36 per cent in January to 75 per cent in July. Since the construction of an additional drain below the seismograph cement floor there has been no occasion to use chloride of calcium for the absorption of moisture. The following are the bi-monthly means:—

| Months. | Humidity. | | Months. | Humidity. | |
|--------------------|-----------|-------------------|-----------------------|-----------|-------------------|
| | Basement. | Seismograph Room. | | Basement. | Seismograph Room. |
| 1908 | | | | | |
| April 1 to 15..... | 48.6 | 45.7 | October 1 to 15..... | 61.7 | 57.9 |
| " 16 to end..... | 49.2 | 47.2 | " 16 to end..... | 72.2 | 54.7 |
| May 1 to 15..... | 58.7 | 60.7 | November 1 to 15..... | 81.3 | 48.2 |
| " 16 to end..... | 72.4 | 73.4 | " 16 to end..... | 44.5 | 43.2 |
| June 1 to 15..... | 69.3 | 72.5 | December 1 to 15..... | 40.9 | 38.6 |
| " 16 to end..... | 76.5 | 74.7 | " 16 to end..... | 37.7 | 36.0 |
| 1909 | | | | | |
| July 1 to 15..... | 65.1 | 73.3 | January 1 to 15..... | 39.0 | 36.3 |
| " 16 to end..... | 71.2 | 75.6 | " 16 to end..... | 38.2 | 37.0 |
| Aug. 1 to 15..... | 67.9 | 73.8 | February 1 to 15..... | 37.5 | 38.1 |
| " 16 to end..... | 64.5 | 71.8 | " 16 to end..... | 36.1 | 34.0 |
| Sept. 1 to 15..... | 60.9 | 71.4 | March 1 to 15..... | 38.0 | 33.5 |
| " 16 to end..... | 67.6 | 71.5 | " 16 to end..... | 40.7 | 38.2 |

During the construction of the large dam across the Ottawa river above the Chaudière falls considerable blasting was done for the foundation in the limestone rock. It was desired to ascertain whether the shocks would be recorded by the seismograph. By request the engineer-in-charge, Mr. J. B. McCrae, kindly noted the time of discharge as given below:—

| | h. | m. | s. | No. of holes. | Dynamite Sticks. |
|------------|----|----|----|---------------|------------------|
| No. 1..... | 12 | 15 | 00 | 3 | 3 |
| 2..... | 12 | 17 | 30 | 5 | 5 |
| 3..... | 12 | 24 | 30 | 4 | 4 |
| 4..... | 12 | 29 | 00 | 11 | 11 |
| 5..... | 12 | 48 | 00 | 8 | 8 |
| 6..... | 12 | 52 | 30 | 16 | 16 |

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The holes were 3 feet apart and about 15 inches deep; one stick of dynamite per hole, and the dynamite 50 per cent. The firing was electric. The nature of the limestone rock is more or less shaly. The distance from the Observatory to the dam is in round numbers 10,000 feet, or 3,050 km. The seismogram for the noon hour was carefully examined for any effect of the above blasts, but it failed to reveal the slightest trace. If there was any it was masked by the very small microseisms that were present on that day. Beside the presence of the minute microseisms two other causes militated against obtaining a record; one, the lack of compactness of the rock over that distance, and the other the very rapid oscillations that would be set up to which the seismograph could not well respond.

EARTHQUAKES RECORDED.

In the following table are given the earthquakes recorded here from January 1, 1908, to March 31, 1909, the end of the fiscal year. On April 1, 1909, began the publication of monthly bulletins of earthquakes and the Göttinger nomenclature adopted by most earthquake stations was also adopted. The preceding three months for 1908 are added in order to have a complete list for that year. Before the adoption of the above nomenclature fewer data were taken from the seismograms than subsequently, which is obvious in the table.

Göttinger Nomenclature or Designations.

Character of the earthquake—

I = noticeable. *II* = conspicuous. *III* = strong.

d = (terræ motus domesticus) = local earthquake (sensible or felt).

v = (" " vicinus) = near " (under 1000 km.)

r = (" " remotus) = distant " (1000 to 5000 km.)

u = (" " ultimus) = very distant earthquake (over 5000 km.)

Phases—

P = (undæ primæ) first preliminary tremors.

S = (" secundæ) second preliminary tremors.

L = (" longæ) long waves (principal portion).

M = (" maximæ) greatest motion in principal portion.

C = (coda) = trailers.

F = (finis) = end of visible disturbance.

Nature of the motion—

i = (impetus) = beginning.

e = (emersio) = appearance.

T = period = twice time of oscillation.

A = amplitude of earth movement, reckoned from zero line.

A_E = E-W component of A } measured in microns (μ).

A_N = N-S

"

A

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RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada. Latitude $45^{\circ} 23' 38''$, Longitude $75^{\circ} 42' 57''$ or $5^{\text{h}} 02^{\text{m}} 51^{\text{s}}.8$ W. Greenwich. Elev. 83^{m} . Time: Mean Greenwich, midnight to midnight. Instruments: Two Bosch photographic horizontal pendulums. Nomenclature: Göttinger. From January 1, 1908, to March 31, 1909.

| No. | Date. | Char. | Phase. | Time. | Period. | AMPLITUDE. | | REMARKS. |
|-----|----------------|-----------|--|--|---------|------------|---------|---|
| | | | | | | A_E | A_N | |
| | 1908 | | — | h. m. s. | s. | μ . | μ . | — |
| 1 | Feb. 1. | <i>I</i> | <i>P</i> <i>L</i> <i>F</i> | 23 25 30 23 33 16 24 00 | | | | |
| 2 | " 9. | <i>I</i> | <i>P</i> <i>L</i> <i>F</i> | 3 28 12 3 35 4 06 | | | | |
| 3 | " 9. | <i>I</i> | <i>P</i> <i>L</i> <i>F</i> | 9 15 08 9 27 9 42 | | | | |
| 4 | " 11. | <i>I</i> | <i>P</i> <i>F</i> | 13 00 48 13 25 | | | | |
| 5 | " 14. | <i>I</i> | <i>P</i> <i>S</i> <i>L</i> <i>F</i> | 9 01 04 9 08 18 9 14 9 40 | | | | |
| 6 | " 14. | <i>I</i> | <i>P</i> <i>S</i> <i>F</i> | 11 44 28 11 47 08 12 00 | | | | |
| 7 | Mar. 3. | <i>I</i> | <i>P</i> <i>F</i> | 23 47 48 24 10 | | | | |
| 8 | " 5. | <i>I</i> | <i>P</i> <i>L</i> <i>F</i> | 2 36 48 3 20 4 00 | 20 | | | |
| 9 | " 5. | <i>I</i> | <i>e</i> <i>F</i> | 14 46 15 03 | | | | |
| 10 | " 25. | <i>I</i> | <i>P</i> <i>S</i> <i>L</i> <i>F</i> | 17 02 00 17 07 34 17 15 18 17 | | | | |
| 11 | " 26. | <i>II</i> | <i>P</i> <i>S</i> <i>M_E</i> <i>M_N</i> <i>F</i> | 23 10 12 23 15 50 23 28 40 23 29 40 2 55 | | | 175 | Chilapa, Mexico, destroyed |
| 12 | " 27. | <i>II</i> | <i>P</i> <i>S</i> <i>L</i> <i>M</i> <i>F</i> | 3 54 12 3 59 44 4 05 28 4 11 6 00 | | 70 | 83 | Same epicentre as above. |
| 13 | April 19. | <i>I</i> | <i>e P</i> <i>S</i> <i>F</i> | 8-16-09 8-24-14 9-00-... | 5 8 | 25 | 5 | Well-marked microseisms mask the <i>P</i> . |
| 14 | April 23. | <i>I</i> | <i>S?</i> <i>L</i> <i>F</i> | 0-07-36 0-52-... 2-16-... | 8 20 | 7 | 2 | Microseisms mask the <i>P</i> . |
| 15 | May 3. | <i>I</i> | <i>S</i> <i>L</i> <i>F</i> | 1-11-20 1-35-... 2-30-... | 8 22 | 3 | 2 | <i>P</i> unrecognizable in the small microseisms. The <i>L</i> of 22 nd continue for 10 min. |

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RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada. Latitude $45^{\circ} 23' 38''$, Longitude $75^{\circ} 42' 57''$ or $5^{\text{h}} 02^{\text{m}} 51^{\text{s}}.8$ W. Greenwich. Elev. 83^{m} . Time: Mean Greenwich, midnight to midnight. Instruments: Two Bosch photographic horizontal pendulums. Nomenclature: Göttinger. From January 1, 1908, to March 31, 1909—*Con.*

| No. | Date. | Char. | Phase | Time. | Period. | AMPLITUDE. | | Remarks. |
|-----|--------------------|------------|--|--|---|---|--|---|
| | | | | | | A_E | A_N | |
| | 1908. | | | h. m. s. | s. | μ | μ | |
| 16 | May 5. | <i>I</i> | <i>P</i> <i>I</i> ₄ <i>F</i> | 6-40 14 7-19 . . 8-30 . . | 5 27 . | 6 . . | 8 . . | Microseisms throughout sheet. <i>L</i> not conspicuous till 7 ^h 19 ^m and continue then for 15 minutes. |
| 17 | May 15. | <i>IIr</i> | <i>iP</i> <i>Pr</i> <i>iS</i> <i>cL</i> <i>M</i> <i>F</i> | 8-39-22 8-41-00 8-45-32 8-50-48 8-53-30 11-10 . . | 12 19 10 33 . . | 3 . . . 140 . | 2 . . . 110 . | On N-S. component for <i>iP</i> period 3 ^s to 4 ^s . Shorter periods of 5 ^s .5 superimposed on <i>L</i> of 33 ^s . Epicentral distance 4400 km. Phases unrecognizable. |
| 18 | June 14 | <i>I</i> | <i>eN</i> <i>cE</i> <i>F</i> <i>e</i> <i>F</i> | 6-07-36 6-09-38 6-33 . . 20-41-52 20 42-04 | 2 6 7 . 2 . | . 8 . . . | | Some windows rattled. Felt in the Observatory and in many places in the city. Epicentral distance 3800 km. |
| 19 | June 16. | <i>Id</i> | <i>F</i> | 20 42-04 | 2 | 8 | 8 | |
| 20 | June 18 | <i>I</i> | <i>iP</i> <i>iS</i> <i>L</i> <i>M</i> <i>F</i> | 10-46-38 10-52-16 11-01-28 11-08 . . 12-00 . . | 4 8 6 6 8 5 . . | 2 4 . 6 . | 2 4 . 7 . | |
| 21 | June 30. | <i>I</i> | <i>c</i> <i>M</i> <i>F</i> | 17-51-30 17-57 . . 18-20 . . | 6 11 . | . 8 . | . 6 . | |
| 22 | July 2. | <i>I</i> | <i>c</i> <i>ME</i> <i>MY</i> <i>F</i> | 13-07-22 13-15 . . 13-16 . . 13-28 . . | . 5 8 . | . 2 . . | . . 4 . | |
| 23 | July 8 | <i>I</i> | <i>P</i> <i>S</i> <i>M</i> <i>F</i> | 12-58-16 13-04-52 13-20 . . 14-11 . . | 6 10 10 . | . . 12 . | . . 4 . | <i>L</i> not well marked. Distance of epicentre 4900 km. |
| 24 | July 16. | <i>Ia</i> | <i>P</i> <i>S</i> <i>M</i> <i>M</i> ₂ <i>F</i> | 17-00-30 17-08-52 17-11 . . 17-54 . . 18-00 . . | 5 7 . 6 . | . . 7 . . | . . 2 10 . | Epicentre 6800 km. Severe earthquake reported from Arica, Chile, but no time stated. |
| 25 | July 19 | <i>I</i> | <i>c</i> <i>F</i> | 14-13-40 14-19 . . | 5 3 . | . . | . . | |
| 26 | July 26. | | | | | | | The first well-marked "saw-tooth" microseisms, period 5.2, since May 10. |
| 27 | August 14. | <i>II</i> | <i>iP</i> <i>iS</i> <i>iL</i> <i>L</i> <i>MY</i> <i>ME</i> <i>F</i> | 0-49-48 0-55-40 1-00-08 1-02-16 1-03-51 1-08-16 2-25 . . | 5 7 8 . 22 . 7 6 . | 2 10 . . . 71 . | 2 6 . . 41 . . | Superimposed by shorter period waves. Distance to epicentre 3900 km. |
| 28 | Aug. 17 | <i>II</i> | <i>iP</i> <i>iS</i> <i>L</i> <i>M</i> <i>LE</i> <i>LY</i> <i>LK</i> <i>LY</i> <i>F</i> | 10-56-00 11-03-07 11-12 . . 11-12-12 11-30 . . 11-36 . . 11-37 . . 11-41 . . 13-30 . . | 4 6 7 . . 32 29 20 21 . | . . . 8 . . . 8 . | . . . 10 | <i>LY</i> <i>LL</i> well-marked unilatory. Distance to epicentre 5400 km. |

SESSIONAL PAPER No. 25a

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada. Latitude $45^{\circ} 23' 38''$, Longitude $75^{\circ} 42' 57''$ or $5^{\text{h}} 02^{\text{m}} 51^{\text{s}}$ W. Greenwich. Elev. 83^{m} . Time: Mean Greenwich, midnight to midnight. Instruments: Two Bosch photographic horizontal pendulums. Nomenclature: Göttinger. From January 1, 1908, to March 31, 1909—*Con.*

| No. | Date. | Char. | Phase | Time. | Period. | AMPLITUDE. | | Remarks. |
|-----|--------------------|----------------------|--|--|---|---|---------------|---|
| | | | | | | A_E | A_N | |
| | 1908. | | | h. m. s. | s. | μ | μ | |
| 29 | Aug. 18 | <i>I</i> | <i>c</i> <i>M</i> <i>F</i> | 11-16-08 11-20-40 11-40-.. | 7 | 4 | .. | Press despatches report an earthquake at Eureka, California, at about $11^{\text{h}} = 3$ a.m. Pacific Standard, for which the adjoining is apparently the record Distance to Eureka 3800 km. |
| 30 | Aug. 19 | <i>I</i> | <i>cP</i> <i>cS</i> <i>M</i> <i>F</i> | 23-42-.. 23-47-.. 23-47-48 24-00-.. | 6 8 | 7 6 | .. | |
| 31 | Aug. 20 | <i>I</i> | <i>c</i> <i>L</i> <i>F</i> | 10-21-.. 10-43-.. 11-33-.. | .. 16-20 .. | .. 4 .. | .. 2 .. | Phases not distinguishable. E-W component the better shown. |
| 32 | Aug. 22 | <i>I</i> | <i>S</i> <i>S</i> <i>M</i> <i>F</i> | 19-31-.. 19-36-22 19-42-00 20-15-.. | 8 .. | 6 .. | .. | |
| 33 | Aug. 23 | <i>I</i> | <i>e</i> <i>F</i> | 19-22-28 19-26-.. | 5 7 .. | .. .. | .. |  |
| 34 | Aug. 29 | <i>I</i> | <i>e</i> <i>M</i> <i>L</i> <i>F</i> | 18-15-18 18-24-10 18-25-.. 19-00-.. | 5-6 .. 20 .. | .. 6 | .. | |
| 35 | Sept. 21 | <i>I_u</i> | <i>e</i> <i>S</i> <i>L_N</i> <i>M_{1N}</i> <i>M_{2N}</i> <i>M_{3N}</i> <i>M_{1E}</i> <i>M_{2E}</i> <i>M_{3E}</i> <i>F</i> | 6-43-? 6-55-47 7-07-40 7-09-32 ..-12-16 ..-14-44 ..-14-40 ..-16-08 ..-18-14 9-00-.. | .. 8 10 10 9.5 8 10 8 8 .. | .. 8 .. 16 16 12 50 37 25 .. | .. | The microseisms mask the <i>P</i> and interfere with the other phases. |
| 36 | Sept. 24 | <i>I</i> | <i>e</i> <i>cL</i> <i>F</i> | 1-05-.. 1-09-40 1-21-.. | .. 16 .. | .. 3 2 | .. | |
| 37 | Oct. 13 | <i>I</i> | <i>iP</i> <i>iS</i> <i>M_N</i> <i>M_E</i> <i>e</i> <i>ME</i> | 5-13-26 5-19-02 5-35-50 5-38-00 6-52-38 7-03-52 | .. 8.5 8 8.3 8 .. | .. 29 35 50 12 14 | .. | <i>iL</i> uncertain. Epicentre 3700 km. A second shock appeared before the other had wholly died out. |
| 38 | Nov. 2 | <i>I</i> | <i>S</i> <i>L</i> <i>M</i> <i>F</i> <i>e</i> <i>F</i> | ..-..-.. 5-54-20 6-43-.. 7-40-.. 8-54-.. 9-20-.. | .. 20 20 .. 12 .. | .. 6 14 | .. | N.-S. component unreadable due to stray microseisms. Some <i>L</i> of 32° Epicentre 6300 km. |
| 39 | Nov. 4 | <i>I</i> | <i>F</i> <i>e</i> <i>F</i> | 7-40-.. 8-54-.. 9-20-.. | .. 12 .. | .. .. .. | .. |  |
| 40 | Nov. 6 | <i>I</i> | <i>P</i> <i>S</i> <i>L</i> <i>M</i> <i>F</i> | 7-31-50 7-38-16 7-46-35 8-02-20 10-30-.. | 6 .. 20 16 .. | 14 29 12 | 7 | Strong microseisms prevailed and partly mask N-S component. Epicentre 5900 km. |

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RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada. Latitude $45^{\circ} 23' 38''$, Longitude $75^{\circ} 42' 57''$ or $5^{\text{h}} 02^{\text{m}} 51^{\text{s}}.8$ W. Greenwich. Elev. 83^{m} . Time: Mean Greenwich, midnight to midnight. Instruments: Two Bosch photographic horizontal pendulums. Nomenclature: Göttinger. From January 1, 1908, to March 31, 1909—*Con.*

| No. | Date. | Char. | Phase | Time. | Period. | AMPLITUDE. | | Remarks. |
|-----|-------------------|----------|-----------|----------|---------|------------|-------|--|
| | | | | | | A_E | A_N | |
| | 1908. | | | h. m. s. | s. | μ | μ | |
| 41 | Nov. 6 | <i>I</i> | <i>e</i> | 23-02 ? | | | | Very strong microseisms prevailed, 10μ , and almost mask N-S component. |
| | | | <i>L</i> | 23-14 ? | ..... | ..... | ..... |  |
| | | | <i>ME</i> | 23-16-50 | 10 | 17 | ..... |  |
| | | | <i>MY</i> | 23-16-50 | 6 | ..... | 10 | |
| 42 | Nov. 9 | <i>I</i> | <i>F</i> | 23-45-.. | | | | Small microseisms mask N-S component except <i>P</i> . No <i>M</i> distinguishable. Epicentre probably 6,500 km. |
| | | | <i>iP</i> | 15-27-00 | 9 | 6 | ..... |  |
| | | | <i>L</i> | 15-44 ? | 19 | ..... | ..... |  |
| | | | <i>F</i> | 17-00-.. | ..... | ..... | ..... |  |
| 43 | Nov. 11 | <i>I</i> | <i>e</i> | 13-39-10 | 5 | | 2 | |
| | | | <i>L</i> | 13-44-40 | ..... | ..... | ..... |  |
| | | | <i>M</i> | 13-56-.. | 14 | 7 | ..... |  |
| | | | <i>F</i> | 15-25-.. | ..... | ..... | ..... |  |
| 44 | Nov. 12 | <i>I</i> | <i>e</i> | 13-51-.. | 13 | 1 | | Very weak: phases unrecognizable. |
| | | | <i>F</i> | 15-00-.. | ..... | ..... | ..... |  |
| 45 | Nov. 19 | <i>I</i> | <i>e</i> | 5-46-.. | 15 | | | No phases recognizable. |
| | | | <i>ME</i> | ..... | 15 | 6 | ..... |  |
| 46 | Nov. 22 | <i>I</i> | <i>F</i> | 6-26-.. | | | | Not recognizable in N-S component. |
| | | | <i>e</i> | 6-45-36 | 8 | 1 | ..... |  |
| | | | <i>L</i> | 6-55-12 | 16 | 2 | ..... |  |
| | | | <i>L</i> | 8-09-24 | 20 | 2 | ..... |  |
| 47 | Nov. 23 | <i>I</i> | <i>F</i> | 8-30-.. | | | | |
| | | | <i>e</i> | 13-04-20 | 6 | 2 | ..... |  |
| | | | <i>M</i> | 13-54-.. | 22 | 6 | ..... |  |
| | | | <i>F</i> | 15-00-.. | ..... | ..... | ..... |  |
| 48 | Nov. 30 | <i>I</i> | <i>P</i> | 21-49-48 | | | | |
| | | | <i>L</i> | 21-56-.. | ..... | ..... | ..... |  |
| | | | <i>MY</i> | 21-57-30 | 6 | ..... | 75 | |
| | | | <i>ME</i> | 21-59-30 | 10 | 125 | ..... |  |
| 49 | Dec. 12 | <i>I</i> | <i>F</i> | 23-30-.. | | | | Microseisms present. |
| | | | <i>eL</i> | 13-43-40 | ..... | ..... | ..... |  |
| | | | <i>LE</i> | 13-46-.. | 32 | 4 | ..... |  |
| | | | <i>L</i> | 13-57-.. | 20 | 4 | 4 | |
| 50 | Dec. 28 | <i>I</i> | <i>F</i> | 14-26-.. | | | | Strong microseisms, but materially decreased after quake. |
| | | | <i>iP</i> | 4-31-04 | 5-6 | 8 | 4 | |
| | | | <i>L</i> | 4-39-42 | 20 | ..... | ..... |  |
| | | | <i>MY</i> | 4-56-30 | 16 | ..... | 10 | |
| | | | <i>ME</i> | 5-00-.. | 16 | 18 | | Epicentre 7,100 km. Postscripts: Calabrian quake. 7,300 km |
| | | | <i>FN</i> | 6-10-.. | ..... | ..... | ..... |  |
| | | | <i>FN</i> | 9-20-.. | ..... | ..... | ..... |  |
| | | | <i>P</i> | 23-22-05 | ..... | ..... | 6 | |
| | Dec. 28 | <i>I</i> | | | | | | No other phases recognizable. E-W component not recorded. |
| | 1909. | | | | | | | |
| 51 | Jan. 12 | <i>I</i> | <i>F</i> | 24-00-.. | | | | Earthquake reported from Vancouver, B.C. |
| | | | <i>P</i> | 0-04-36 | 4 | 3 | 4 | |
| | | | <i>F</i> | 0-22-.. | ..... | ..... | ..... |  |
| | | | <i>e</i> | 10-26-.. | ..... | ..... | ..... |  |
| 52 | Jan. 12 | <i>I</i> | <i>F</i> | 10-37-.. | | | | |
| | | | <i>F</i> | 10-37-.. | ..... | ..... | ..... |  |
| 53 | Jan. 12 | <i>I</i> | <i>e</i> | 12-30-.. | ..... | ..... | ..... |  |
| | | | <i>M</i> | 12-35-.. | 12-16 | 4 | 2 | |
| | | | <i>F</i> | 12-55-.. | | | | No phases recognizable. |
| 54 | Jan. 21 | <i>I</i> | <i>e</i> | 21-43-.. | | | | |
| | | | <i>MY</i> | 21-47-30 | 6.1 | | 5 | |
| | | | <i>ME</i> | 21-48-40 | 6.7 | 6 | | |
| | | | <i>F</i> | 22-05-.. | | | | |

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RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada. Latitude $45^{\circ} 23' 38''$, Longitude $75^{\circ} 42' 57''$ or $5^h 02^m 51^s$ W. Greenwich. Elev. 83^m . Time: Mean Greenwich, midnight to midnight. Instruments: Two Bosch photographic horizontal pendulums. Nomenclature: Göttinger. From January 1, 1908, to March 31, 1909—Con.

| No. | Date. | Char. | Phase | Time. | Period. | AMPLITUDE. | | | REMARKS. |
|-----|-------------------|-------|----------------|-----------|---------|------------|---------|--|--|
| | | | | | | A_N | A_E | | |
| | 1909. | | | h. m. s. | s. | μ . | μ . | | |
| 55 | Jan. 23..... | I | P | 3-01-13 | | | | | Epicentre estimated at 9,400 km. |
| | | | S | 3-11-42 | ..... | ..... | ..... |  |  |
| | | | L | 3-28-? | ..... | ..... | ..... |  |  |
| | | | L | 3-32-.. | 24 | ..... | ..... |  |  |
| | | | M _N | 3-35-.. | 24 | ..... | 6 | | |
| | | | M _E | 3-37-.. | 22 | 8 | | | |
| | | | F | 4-50-.. | | | | | |
| 56 | Feb. 9. | I | e | 12-01-.. | | | | | Well-marked microseisms prevail. |
| | | | L | 12-06-.. | 20 | ..... | ..... |  |  |
| | | | F | 12-21-.. | ..... | ..... | ..... |  |  |
| 57 | Feb. 16..... | I | P | 16-31-20? | | | | | Epicentre 8,400 km. |
| | | | L | 16-54-20 | 6 | ..... | ..... |  |  |
| | | | M _N | 16-55-00 | 6 | ..... | 30 | | |
| | | | M _E | 16-55-40 | 7 | 40 | ..... |  |  |
| | | | F | 17-35-.. | ..... | ..... | ..... |  |  |
| 58 | Feb. 22 | I | P | 9-40-00 | | | | | Microseisms present. |
| | | | S | 9-45-06 | | | | | Epicentre 3,500 km. |
| | | | L _E | 9-48-29 | 7 | ..... | ..... |  |  |
| | | | M | 9-52-40? | 7 | 20 | ..... |  |  |
| | | | F | 11-20-.. | ..... | ..... | ..... |  |  |
| 59 | Feb. 26. | I | P | 16-53-35 | | | | | Well-marked microseisms. |
| | | | S | 16-59-16 | ..... | ..... | ..... |  |  |
| | | | L | 17-01-23 | ..... | ..... | ..... |  |  |
| | | | M | 17-05-12 | 12 | 50 | ..... |  |  |
| | | | F | 17-38-.. | ..... | ..... | ..... |  |  |
| 60 | Mar. 12 } 13 } | I | e | 23-42-.. | | | | | |
| | | | L | 0-07-.. | ..... | ..... | ..... |  |  |
| | | | M _E | 0-14-.. | 20 | 6 | ..... |  |  |
| | | | F | 1-38-.. | ..... | ..... | ..... |  |  |
| 61 | Mar. 13..... | I | P | 14-42-20 | ..... | ..... | ..... |  |  |
| | | | S | 14-52-40 | | | | | |
| | | | L | 15-16-32 | 20 | | | | |
| | | | M | 15-19-30 | 27 | 6 | | | |
| | | | F | 17-00-.. | | | | | |
| 62 | Mar. 18..... | I | eL | 0-03-40 | 24 | | | | Irregularities due to winds and microseisms mask the phases. |
| | | | F | 0-20-.. | ..... | ..... | ..... |  |  |

During this period of fifteen months sixty-two earthquakes were recorded and but one of them of Canadian origin, and that one in the vicinity of Ottawa. Popularly the severity of an earthquake is measured by the destruction of life and property, which is however by no means the criterion for the seismologist when considering it as a tectonic movement. There were three earthquakes by which much destruction was done: the two shocks of March 26-27 by which Chilapa, on the Pacific slope of Mexico was destroyed; then the great disaster of Messina, also spoken of as the Calabrian earthquake; and the Persian one of January 23, 1909.

Most of the other quakes probably occurred at sea and hence give us no evidence from the epicentre or central area of disturbance unless it be through the breaking of submarine cables. However, with the great improvement of earthquake instruments in recent years, with increased sensitiveness and more accurate time-scale, it

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will now be possible to locate with a fair degree of accuracy every earthquake that is recorded at a number of widely separated stations. There is yet room for improvement in sensitiveness, especially for recording the first preliminary tremors, and also in the time record; the clock correction, if any, should be within a second of time. The time-scale on our photographic seismogram is made by a shutter, actuated electrically by our normal standard mean time clock, and so far has never required a correction of a second. The light is cut off every minute for two seconds and the 60th minute is omitted in order to identify the hour.

With well marked phases on a seismogram and good time-scale, the distance to the epicentre of a tectonic quake can be obtained within say 100 km. or 60 miles. The direction of the seat of disturbance, however, can not be so well deduced. Were the matter through which the earthquake waves are propagated homogeneous, then the components of the two pendulums placed generally in the N.-S. E.-W. directions at each station would furnish some indication of the direction sought, and thus enable each station to obtain at least an approximate position for the epicentre. The complete analysis of the seismograms is yet remote.

That the velocity of the first and second preliminary tremors or longitudinal and transverse waves respectively is a function of the distance is well illustrated in the accompanying table which has been compiled of the Messina earthquake. Time of occurrence at Messina is taken as 4^h 20^m Greenwich mean time (Professor Rizzo). The seismogram records were obtained from the various subjoined stations, and the distances were directly taken from our 30-inch globe with a flexible steel tape especially graduated to represent 10,000 km. for the quadrant. A globe of this size with such a graduated tape is of great service in the study of earthquakes and their epicentres.

P. S. L. represent respectively the time of arrival of the first preliminary, the second preliminary, and the long waves.

MESSINA EARTHQUAKE.

| Place. | Distance. | Middle ordinate to Chord. | <i>P</i> | | | <i>S</i> | | | <i>L</i> | | | Velocity per Minute. | | | $\frac{S}{P}$ |
|-----------------|-----------|---------------------------|----------|----|----|----------|----|----|----------|----|----|----------------------|----------|----------|---------------|
| | | | <i>P</i> | | | <i>S</i> | | | <i>L</i> | | | <i>P</i> | <i>S</i> | <i>L</i> | |
| | km. | km. | h | m | s | h | m | s | h | m | s | km. | km. | km. | |
| Ottawa..... | 7200 | 992 | 4 | 31 | 04 | 4 | 39 | 42 | .. | .. | .. | 651 | 365 | ..... | .56 |
| Washington..... | 7650 | 1116 | 4 | 31 | 23 | 4 | 40 | 30 | .. | .. | .. | 672 | 373 | ..... | .56 |
| Tiflis..... | 2550 | 128 | 4 | 25 | 33 | 4 | 29 | 50 | 4 | 35 | 20 | 458 | 259 | 166 | .57 |
| Cartuja..... | 1700 | 56 | 4 | 23 | 35 | 4 | 26 | 40 | 4 | 27 | 50 | 474 | 255 | 217 | .54 |
| Sarajevo..... | 700 | 10 | 4 | 21 | 51 | 4 | 23 | 09 | 4 | 23 | 54 | 378 | 222 | 180 | .59 |
| Belgrade..... | 850 | 14 | 4 | 22 | 09 | 4 | 23 | 11 | 4 | 24 | 12 | 395 | 267 | 202 | .68 |
| Laibach..... | 900 | 16 | 4 | 22 | 18 | 4 | 23 | 33 | 4 | 24 | 16 | 391 | 254 | 211 | .65 |
| Vienna..... | 1100 | 24 | 4 | 22 | 55 | 4 | 25 | 17 | 4 | 25 | 16 | 377 | 208 | 175 | .55 |
| Cracow..... | 1400 | 38 | 4 | 23 | 23 | 4 | 25 | 59 | 4 | 26 | 48 | 413 | 234 | 206 | .56 |
| Hamburg..... | 1750 | 60 | 4 | 24 | 16 | 4 | 27 | 18 | 4 | 28 | 12 | 410 | 240 | 213 | .58 |
| Aachen..... | 1600 | 56 | 4 | 23 | 53 | 4 | 26 | 38 | .. | .. | .. | 412 | 241 | ..... | .58 |
| Toronto..... | 7500 | 1073 | 4 | 31 | 12 | 4 | 39 | 48 | 5 | 00 | 00 | 670 | 379 | 187 | .57 |
| Victoria..... | 9550 | 1709 | 4 | 33 | 12 | 4 | 43 | 36 | 5 | 06 | 36 | 723 | 405 | 205 | .56 |
| Mean..... | | | | | | | | | | | | 196.2 | | | |
| Per second..... | | | | | | | | | | | | 3.27 | | | |

The ratio $\frac{S}{P}$ is pretty constant, with the exception of the three stations, Sarajevo, Belgrade and Laibach, which are all less than 1,000 km. from the epicentre, and for which the ordinates to the chords are small, from 10 to 16 km., not reaching to the supposed layer of isostatic adjustment.

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The degree of accuracy of the time element in the records for deducing velocities is of far more consequence for close stations than for very distant ones. However in the above, which comprise all the data available at the time, there does not appear to be any serious discrepancy in the reading of the various seismograms. The *L* waves show themselves conspicuously as being propagated over the same medium for all stations, that is, along the surface, by having the same velocity. Thus the velocity from origin to Cracow is the same as to Victoria, seven times as distant. Although there are some variations in the velocity of the surface waves, they are wholly independent of the distance, and most likely attributable to the difficulty of sometimes identifying the arrival of the long waves in the medley of the other waves and their reflections which precede.

As the time of the occurrence of the severe earthquake in Persia of January 23, 1909, was not reported, and the time service in those regions is in any case probably very unsatisfactory with reference to Standard or Greenwich time, an attempt has been made to determine the time of the occurrence at the epicentre, based on the press despatch that the epicentre was at Bahrein, and on the times of arrival of the first and second preliminary tremors (*P* and *S*) at various stations of which the records had been received. The geographical position of Bahrein is taken from Stieler's *Hand Atlas*, $\varphi = 33^{\circ} 30'$, $\lambda = 49^{\circ} 30'$ E. Greenwich. The distances are taken from our 30-inch globe.

In the following table the computed transmission times V_1 , V_2 for the *P* and *S* are interpolated from the Wiechert-Zeppritz values compounded from the Indian earthquake of 1905, the Calabrian one of 1905, and the San Francisco one of 1906.

For *L* the velocity is taken at 4 km. per second.

EARTHQUAKE OF JANUARY 23, 1909.

BAHREIN, PERSIA.

$\phi = 33^{\circ} 30'$, $\lambda = 49^{\circ} 30'$ E. OF GR.

GREENWICH TIME.

| Station. | Dis- tance. km. | Ordin- ate. km. | Seismograms. | | | Computed. | | | Deduced time at Epicentre. | | |
|---------------------|-----------------------|-----------------------|--------------|-----------|-----------|-----------|------------|-----------|-------------------------------|---------|------------|
| | | | <i>P</i> | <i>S</i> | <i>L</i> | V_1 | V_2 | <i>B</i> | $P-V_1$ | $S-V_2$ | <i>L-B</i> |
| | | | h m s | h m s | h m s | m s | m s | m s | h m s | h m s | h m s |
| Ottawa | 9750 | 1778 | 3 01 13 | 3 11 42 | 3 28 . . | 12 54 23 | 38 40 37 | 2 48 13 | 2 48 04 | 2 47 23 | |
| Hamburg. | 3830 | 287 | 2 55 14 | 3 00 36 | 3 03 12 | 7 07 12 | 40 15 57 | 48 07 . . | 47 56 . . | 47 15 | |
| Aachen. | 4020 | 315 | 2 55 33 | 3 01 05 | 3 04 56 | 7 22 13 | 06 16 45 | 48 12 . . | 47 59 . . | 48 11 | |
| Trieste. | 3330 | 217 | 2 54 42 | 2 59 42 | 3 04 41 | 6 21 11 | 22 13 52 | 48 20 . . | 48 20 . . | 50 49 | |
| *Sarajevo. | 2920 | 168 | 2 55 30 | 3 00 09 | 3 03 36 | 5 52 10 | 24 12 10 | 48 38 . . | 48 45 . . | 50 26 | |
| Cracow. | 3060 | 183 | 2 54 08 | 2 58 59 | 3 | 6 00 10 | 43 | 48 08 . . | 48 16 . . | 50 . . | |
| Vienna | 3200 | 240 | 2 54 18 | 2 59 10 | 3 00 56 | 6 13 11 | 07 13 20 | 48 05 . . | 48 03 . . | 47 36 | |
| Tiflis. | 1030 | 21 | 2 50 40 | 2 | 2 | 2 19 4 | 04 | 48 21 . . | 48 | 49 24 | |
| Strassburg. | 3850 | 250 | 2 55 09 | 3 00 26 | 3 05 26 | 7 09 12 | 40 16 02 | 48 00 . . | 47 46 . . | 49 24 | |
| Laibach. | 3300 | 213 | 2 54 20 | 2 59 15 | 3 04 17 | 6 21 11 | 16 13 45 | 47 59 . . | 47 59 . . | 50 32 | |
| Belgrade. | 2650 | 137 | 2 53 26 | 2 57 53 | 3 01 42 | 5 27 9 | 42 11 02 | 47 59 . . | 48 11 . . | 50 40 | |
| Cartuja. | 4820 | 450 | 2 56 33 | 3 03 05 | 3 07 30 | 8 20 14 | 48 20 05 | 48 13 . . | 48 17 . . | 47 25 | |
| Washington. | 10300 | 1972 | 3 01 22 | 3 12 05 | 3 30 . . | 13 18 24 | 28 42 55 | 48 04 . . | 47 37 . . | 47 05 | |
| Mean. | | | | | | | | | 2 48 11 | 2 48 06 | 2 48 48 |

It will be observed from the above table that the mean time deduced from the *P* agrees within 5 seconds of the mean of the deduced time from the *S*, so that one feels justified in giving for the time of the occurrence of the quake in Persia 2^h 48^m 5^s.

* Times evidently one minute too late.

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Greenwich time. The agreement between the two independent values $P - V_1$ and $S - V_1$ for any station is satisfactory too; in several cases the times are absolutely co-incident. However, we cannot always be sure of individual seconds in reading P and S on the seismogram.

A greater difficulty we encounter when trying to read on the seismogram the arrival of the long waves, L , and this is manifested in the last column, which in the ideal condition we should expect to agree with the other two. The discordances in the last column of individual values from the general mean ($2^h 48^m 08^s$) of the other two columns is not attributable to the assumption of 4 km. as the velocity of the long waves per second, but rather to the reading of the various seismograms. For, taking $T = 2^h 48^m 08^s$ as the time of the occurrence of the quake and solving by least squares for the velocity of the long waves we get 238 km. per minute, which is practically the same as 4 km. per second, the quantity used.

If we arrange $L - T$ in the order of magnitude and divide the resulting time into the respective distance of the station from the epicentre it will be found that there is a tendency for the greater distance to give the greater velocity; the extreme values being Hamburg 4.24 km., and Belgrade 3.26 km. per second.

We may recall the table of the Calabrian or Messina quake, which gave for Belgrade 3.36 km., and for Hamburg 3.55 km., and the general mean 3.27 km. In no case for that quake was a velocity obtained as high as 4 km., the highest being for Cartuja 3.61 km. per second.

Judging from our seismograms here, it is believed that the discordances obtained for the velocity of the long waves are mostly or wholly attributable to the uncertainty of identifying, midst the complexity of longitudinal and transverse waves and their reflections which precede, the arrival of the surface or long waves.

Some of the stations on this continent failed to get a record of the first preliminary tremors, due to lack of sensitiveness of the instrument. For distant quakes not only the diminished force of the longitudinal impulse comes into play, but also the horizontal component of that impulse, so that distance very materially militates against the recording of the first preliminary tremors.

The following table is a compilation of the two preceding ones, and arranged in order of distance with the corresponding middle ordinate to the chord, and the mean velocity of the first preliminary tremors, P , or longitudinal waves in kilometres per minute.

FOR MESSINA AND BAHREIN EARTHQUAKES.

| Place. | Distance. | Ordinate. | Velocity P. | Place. | Distance. | Ordinate. | Velocity P. |
|----------|-----------|-----------|-------------|------------|-----------|-----------|-------------|
| | km. | km. | km. | | km. | km. | km. |
| Sarajevo | 700 | 10 | 378 | Vienna | 3,200 | 200 | 519 |
| Belgrade | 850 | 14 | 395 | Laiabach | 3,300 | 213 | 532 |
| Laiabach | 900 | 16 | 391 | Trieste | 3,330 | 217 | 507 |
| Tiflis | 1,030 | 21 | 407 | Hamburg | 3,830 | 287 | 540 |
| Vienna | 1,100 | 24 | 377 | Strassburg | 3,850 | 290 | 549 |
| Cracow | 1,400 | 28 | 413 | Aachen | 4,020 | 315 | 542 |
| Aachen | 1,600 | 50 | 412 | Cartuja | 4,820 | 450 | 573 |
| Cartuja | 1,700 | 56 | 474 | Ottawa | 7,200 | 992 | 651 |
| Hamburg | 1,750 | 60 | 410 | Toronto | 7,500 | 1,073 | 670 |
| Tiflis | 2,550 | 124 | 458 | Washington | 7,650 | 1,116 | 672 |
| Belgrade | 2,650 | 137 | 500 | Victoria | 9,550 | 1,709 | 723 |
| Sarajevo | 2,920 | 163 | 396 | Ottawa | 9,750 | 1,778 | 745 |
| Cracow | 3,060 | 183 | 510 | Washington | 10,300 | 1,972 | 778 |

There are some discrepancies in the table, notably the one for Sarajevo. From information received it would appear that it is mostly due to an error or inaccuracy

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in time scale. If the phenomenal progress that seismology has made in recent years continues, such discrepancies will disappear and data of a high order of precision will be obtained, upon which a permanent structure can be raised.

There are now some 200 earthquake stations distributed over the earth, and the seismograms furnished by them are far from homogeneous, and are far from equal merit and value for studying the geophysical problems for which they are obtained. The first order of precision to be aimed at is that of time. Seismology demands now that the time recorded should be accurate within at least one second. As standard time is now so widely distributed by telegraph, there seems no reason why the time of every earthquake station should not be controlled by the time from some astronomical observatory. In order to be able to read to one second on the seismogram the time scale should be about 90cm. to the hour, or 15mm. to the minute; *i.e.*, 1mm. would represent 4 seconds. There is a limit to the speed of the revolving cylinder, for if it is too great, although the time could then be more accurately read, yet, waves with small amplitudes would become so flattened as to be scarcely recognizable. A further demand for precision, is that the instrument be highly sensitive in order that the first impulse of the first preliminary tremors is recorded, and that damping co-efficient should approach the limit of aperiodicity for the pendulum, in order that the seismogram may represent fairly well the earth movements and free from those of the pendulum itself.

CANADIAN EARTHQUAKES.

Looking at a geological map of Canada one is immediately impressed with the fact that the greater part of the Dominion, running from the Gulf of St. Lawrence past Hudson bay and on to Great Bear lake and the Arctic ocean, is composed essentially of archæan rock, that is, of the oldest formation on the earth. This is probably the largest area of archæan rock on the earth, being closely followed by the Scandinavian peninsula and Finland. As earthquakes are intimately associated with the age of rock formation, the more recent being more subject to disturbances than the older ones, we may say that broadly speaking the vast area above referred to will always be fairly free from earthquakes, for its compact and more or less homogeneous nature is not so well adapted to the adjustment of the strains of the earth's crust, which is the cause of earthquakes, as the newer formations are, which are intersected by dikes and faults, and which exhibit stratification and folding with, consequently, lines and surfaces of weakness.

In the St. Lawrence valley, westward from Quebec to Lake Huron, we have formations of the Palæozoic age, and also to the south of the St. Lawrence covering New Brunswick and Nova Scotia. In the whole of eastern Canada from Nova Scotia to near the mouth of the Mackenzie river, a distance of nearly 3,000 miles, no formations more recent than those of the Palæozoic age are found. In western Canada the newer formations occur; the Great Plains being represented by the Cretaceous and Tertiary eras. The mainland Pacific coast of British Columbia is almost wholly 'coast granite,' while the interior is largely represented by the Miocene period of the Tertiary era. The nature, composition and structure of the formation itself may, *per se*, directly lead through gravitational effect to earthquakes. While on the other hand such formation may lend itself to the adjustment of stresses imposed upon it from neighbouring regions, *e.g.* the sea or ocean. So much is obvious, that whatever reason we may assign as the contributory cause of an earthquake, where it occurs is necessarily the weak spot for the area under strain. From historic records and of late years from instrumental records the seismic areas of the earth are fairly well known, but why the degree of seismicity should vary in different regions is open to considerably more elucidation. The Indo-Pacific archipelago, including Sumatra, Java, New Guinea and the Philippines is the most seismic region of the earth for the larger quakes, while the eastern coast of Canada is fairly immune.

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The more or less severe, but not destructive, earthquakes that have visited eastern Canada are all associated more or less directly with the 'Great Champlain and St. Lawrence fault,' running from the gulf up the river to Quebec and then curving southwesterly to Lake Champlain. Of these the quakes of 1663, 1791, 1860 and 1870 are the most noted. The first one has gained a certain celebrity from its exaggerated description. This earthquake, which lasted about six months, occurred during the French occupation. We may regard the record of this as the beginning of our literature on seismology, and hence give it a place here, although its scientific value is rather circumscribed.

From a manuscript in the Jesuits' College at Quebec the editor of '*Hochelaga Depicta*' took the following account of this quake:—

'On the 5th of February, 1663, about half past five in the evening a great rushing noise was heard throughout the whole extent of Canada. This noise caused the people to run out of their houses into the streets, as if their habitations had been on fire; but instead of flames or smoke, they were surprised to see the walls reeling backwards and forwards, and the stones moving, as if they were detached from each other. The bells sounded by the repeated shocks. The roofs of the buildings bent down, first on one side and then on the other. The timbers, rafters and planks cracked. The earth trembled violently, and caused the stakes of the palisades and palings to dance in a manner that would have been incredible had we not actually seen it in many places. It was at this moment every one ran out of doors. There were to be seen animals flying in every direction, children crying and screaming in the streets; men and women seized with affright, stood horror-struck with the dreadful scene before them, unable to move, and ignorant where to fly for refuge from the tottering walls and trembling earth, which threatened every instant to crush them to death, or to sink them into a profound and unmeasurable abyss. Some threw themselves on their knees in the snow, crossing their breasts and calling on their saints to relieve them from the dangers with which they were surrounded. Others passed the rest of this dreadful night in prayer, for the earthquake ceased not, but continued at short intervals, with a certain undulating impulse, resembling the waves of the ocean, and the same qualmish sensations, or sickness of the stomach, was felt during the shocks as is experienced on a vessel at sea. . . . The violence of the earthquake was greatest in the forests, where it appeared as if there was a battle raging between the trees; for not only their branches were destroyed, but even their trunks are said to have been detached from their places and dashed against each other with inconceivable violence and confusion, so much so, that the Indians in their figurative manner of speaking, declared that all the forests were drunk. The war also seemed to be carried on between the mountains, some of which were torn from their beds and thrown upon others, leaving immense chasins in the places from whence they had issued, and the very trees with which they were covered sunk down, leaving only their tops above the surface of the earth; others were completely overturned, their branches buried in the earth and the roots only remained above ground. During this general wreck of nature the ice, upwards of six feet thick, was rent and thrown up in large pieces, and from the openings in many parts, there issued thick clouds of smoke, or fountains of dirt and mud, which spurted up to a very considerable height. The springs were either choked up or impregnated with sulphur,—many rivers were totally lost, others were diverted from their course and their waters entirely corrupted. Some of them became yellow, others red, and the great River of St. Lawrence appeared entirely white as far down as Tadousac. This extraordinary phenomenon must astonish those who know the size of the river, and the immense body of water in various parts, which must have required such an abundance of matter to whiten it. They write from Montreal that during the earthquake they plainly saw the stakes of the picketing or palisades jump up as if they had been dancing; and that of two doors in the same room, one opened and the other shut of their own accord; that the

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chimneys and tops of the houses bent like branches of trees agitated with the wind; that when they went to walk they felt the earth following them and rising at every step they took, sometimes sticking against the soles of their feet and other things in a very forcible and surprising manner. . . . From Three Rivers they write that the first shock was the most violent, and commenced with a noise resembling thunder. The houses were agitated in the same manner as the tops of trees during a tempest, with a noise as if fire was crackling in the garrets. The shock lasted half an hour, or rather better, though the greatest force was properly not more than a quarter of an hour; we believe there was not a single shock which did not cause the earth to open either more or less. As for the rest, we have remarked that, though this earthquake continued almost without intermission, yet it was not always of an equal violence. Sometimes it was like the pitching of a large vessel which dragged heavily at her anchors; and it was this motion that caused many to have a giddiness in their heads and qualmishness at their stomachs. At other times the motion was hurried and irregular, creating sudden jerks, some of which were extremely violent; but the most common was a slight tremulous motion, which occurred frequently with little noise. Many of the French inhabitants and Indians, who were eye-witnesses to the scene, state that a great way up the river of Trois Rivières, about 18 miles below Quebec, the hills which bordered the river on either side, and which were of a prodigious height, were torn from their foundations and plunged into the river, causing it to change its course and spread itself over a large tract of land recently cleared; the broken earth mixed with the waters, and for several months changed the colour of the great River St. Lawrence, into which that of Trois Rivières disembogues itself. In the course of this violent convulsion of nature, lakes appeared where none ever existed before; mountains were overthrown, swallowed up by the gaping, or precipitated into adjacent rivers, leaving in their places frightful chasms or level plains; falls and rapids were changed into gentle streams, and gentle streams into falls and rapids. Rivers in many parts of the country sought other beds or totally disappeared. The earth and the mountains were entirely split and rent in innumerable places, creating chasms and precipices whose depths have never yet been ascertained. Such devastation was also occasioned in the woods, that more than a thousand acres in one neighbourhood were completely overturned, and where but a short time before nothing met the eye but one immense forest of trees, now were to be seen extensive cleared lands apparently cut up by the plough. . . . At Tadousac, about 150 miles below Quebec on the north side, the effect of the earthquake was not less violent than at other places; and such a heavy shower of volcanic ashes fell in that neighbourhood, particularly in the River St. Lawrence, that the waters were as violently agitated as during a tempest. Near St. Paul's bay, about 50 miles below Quebec on the north side, a mountain about a quarter of a league in circumference, situated on the shore of the St. Lawrence, was precipitated into the river, but, as if it had only made a plunge, it rose from the bottom and became a small island, forming with the shore a convenient harbour, well sheltered from all winds. Lower down the river, towards Point Alouettes, an entire forest of considerable extent was loosened from the main bank and slid into the River St. Lawrence, where the trees took fresh root.

'There are three circumstances, however, which have rendered this extraordinary earthquake particularly remarkable: the first is its duration, it having continued from February to August, that is to say, more than six months almost without intermission. It is true, the shocks were not always equally violent. In several places, as towards the mountain behind Quebec, the thundering noise and trembling motion continued successively for a considerable time. In others, as towards Tadousac, the shock continued generally for two or three days at a time with much violence. . . . The second circumstance relates to the extent of this earthquake, which we believe was universal throughout the whole of New France, for we learn that it was felt from l'Isle Percée and Gaspé, which are situate at the mouth of the St. Lawrence to

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beyond Montreal, as also in New England, Acadia and other places more remote. As far as it has come to our knowledge, this earthquake extended more than 600 miles in length and about 300 in breadth. Hence 180,000 square miles of land were convulsed in the same day and at the same moment.

'The third circumstance, which appears the most remarkable of all, regards the extraordinary protection of Divine Providence which has been extended to us and our habitations; for we have seen near us the large openings and chasms which the earthquake occasioned, and the prodigious extent of country which has either been totally lost or hideously convulsed, without our losing either man, woman or child, or even having a hair of their heads touched.'

We might add a fourth circumstance, and that is, that the narrators of the above anticipated the sensationalism of our 'yellow' journals by two and a half centuries.

The following is a list of the slight local shocks occurring in Canada from January 1, 1908, to April 30, 1909. The items were gathered from the daily press:—

1908.

May 12.—A very perceptible shock of earthquake was felt in Yarmouth, N.S., and vicinity a few minutes before 12 on Wednesday night. Houses shook and trembled and there was a loud report as of heavy thunder. No damage has been reported. It was bright moonlight and calm at the time. It was likewise felt in Digby, Annapolis and Shelburne counties.

June 16.—A distinct shock occurred at Ottawa, and was recorded by the seismograph at 3^h 41^m 52^s p.m., the pulsations lasting 16 seconds. It was generally felt; windows rattled, and some heard a loud rumbling sound. On the Rossi-Forel scale the intensity would be designated by IV. It was felt over an area about 60 miles in diameter.

July 17.—Quite a distinct shock was felt at Arnprior at 2^h 10^m a.m. A great many citizens felt it. The quake was accompanied by a noise similar to that of a large building falling.

August 8.—Despatches from the up-river section of New Brunswick report earthquake shocks in several places this morning. At Hartland there were three shocks at 1, 4 and 7 a.m. Plaster fell from the ceiling in one building. In Fredericton and vicinity there was a shock felt about 7 o'clock. Thunder and lightning and very heavy rain were experienced during the night.

November 30.—An earthquake travelling apparently from north to south threw the inhabitants of the town of Skidegate, Queen Charlotte islands, into a state of nervous apprehension in the afternoon of November 30, according to news brought south by the fishing steamer *Celestial Empire*, which reached Vancouver yesterday morning (December 9) from the northern halibut banks. It was estimated that the shock lasted fully seven seconds. No other tremors were felt, greatly to the relief of the people of the town, who became somewhat alarmed on observing that two Indian shacks had been thrown to the ground. The buildings knocked down were old, half-tumbled-down affairs.

1909.

January 11.—Nearly all parts of southern British Columbia and Washington Territory, across the international boundary, were shaken by an earthquake at 3.45 p.m., Pacific standard time of January 11, the quake lasting from 10 to 20 seconds. No damage was done but the alarm was very great. Beyond the breaking of some crockery in a few homes in Victoria, there was little damage caused. Comox, Alberni, Pachena, Bamfield and other points report having felt the shock, Bamfield stating that two tremors were felt, while Estevan reports that no shock was experienced there. At Port Townsend, across the boundary line, in many places where water pipes lay in the frozen ground, the earthquake broke the pipes and flooded houses.

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January 31-February 1.—Three distinct earthquake shocks were felt in Montreal last night. The first shock was felt at 11^h 30^m p.m., the second at 11^h 45^m, and the third and most severe at 3^h 20^m a.m. People were awakened all over the city. The rattling of glassware and crockery was heard distinctly. A peculiar feature was the howling of dogs all over the city. Loud cracking as though houses were being severely strained was noticed everywhere. A number of houses are cracked as the result of the quakes, also some sidewalks.

February 3.—At about 4 a.m. quite a number of people in Montreal were aroused by an unusual sound and a slight sense of vibration, which lasted only a very short time and was not repeated. It was less severe than the preceding one of two days ago.

Examining the geological areas for the above places it is not difficult to understand that local shocks may occur there. The complexity of the formations; the differences in composition, in density, in elasticity; the many faults and dikes; the numerous surfaces of contact; the constant gravitational effect, all conspire towards the interruption of a continuous gradual adjustment of stresses and strains, so that at times these adjustments, though very minute, are abrupt and manifest themselves as local shocks. That these adjustments are very small is shown by the very small acceleration produced. Acceleration is the measure of intensity of an earthquake.

In the above local shocks there is only one, that for Ottawa, for which direct measures were obtained. We find from them that the acceleration produced was 2.4 millegals.

The unit of acceleration in the C. G. S. system is called a 'gal', i.e., the acceleration of 1cm per second, per second; hence for gravity at latitude 45° we have 980.60 gals. A millegal is the thousandth of a gal.

Small local shocks like the above may occur almost anywhere, at least in many localities over the southern part of Canada from Nova Scotia to British Columbia.

It may be remarked, however, that when we reach the Pacific coast we enter upon ground adapted to tectonic or the larger quakes. Vancouver island, Queen Charlotte islands and the smaller islands all lie in comparatively shallow water, but immediately to the west lies the deep trough of the Pacific, adapted for breeding seismic disturbances on a large scale.

MICROSEISMS.

In order to treat this subject as fully as the data and records here warrant, some of the matter published last year is here incorporated for the sake of completeness.

Under the designation microseisms, are included all pulsations not directly attributable to what are generally known as earthquakes, which give abrupt, more or less violent, and momentary movements of the earth's crust, the effect of which may, however, continue for some hours. Attempts have been made to classify these microseisms according to their cause, but so far without complete success. During the past year the writer has paid considerable attention to these disturbances, and in doing so has studied and compared the daily seismograms with our daily micro-barograms, our weekly aneroid barograms and also with the daily weather maps, which give the isobars at 8 a.m. for Canada and the United States, roughly between latitudes 25° and 55°, and the Atlantic and Pacific oceans. The micro-barogram exhibits particularly well very rapid fluctuations of pressure as manifested by local and often gusty winds, the counterpart of which is always represented on the seismogram by irregular movements and not by microseisms. The average time of the beginning of the seismogram sheet is about 10 a.m., so that the above isobars and gradients dependent upon them are for a time preceding the former by two hours. From the examination of the local barogram alone not much information can be gathered as to the behaviour of the seismograph except when very rapid and marked fluctuations, say a millimetre or more, take place in the pressure, comparable with the 'pumping' of a mercurial

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barometer at sea. The barometer may show little or no change in pressure at a given place, yet areas of 'High' and 'Low' (barometer) may be rushing along to the north and south of it, setting up vibrations or pulsations of the earth's surface that may be markedly felt at a given place by the seismograph. Similarly from a large rise or fall of the barometer during 24 hours at a given place alone, we can draw no gradients to determine the atmospheric movements; the position of the isobars and 'Highs' and 'Lows' being unknown. We have simply the record of the vertical movement of pressure at one point. The isobars on the Weather Map are drawn at intervals of one-tenth inch difference of pressure. The normal to the isobars is called the gradient, and when spoken of, generally refers to the gradient between a 'High' and a 'Low' passing through Ottawa. An examination has been made during the year of the daily seismograms and the daily Weather Maps, including the isobars or position of 'Highs' or 'Lows' and the forecast for the Ottawa regions with reference to winds and storms. This examination furnishes the data upon which the conclusions depend. As the Observatory is not yet supplied with an anemometer and pressure gauge for comparison of the dynamical conditions, we are at present dependent upon the daily forecast.

It may be stated at the outset, before discussing the preceding data, that there is never a day in the year on which some trace of microseisms can not be seen on a seismogram from a Bosch photographic seismograph. It is all a matter of degree. That microseisms should be ever present is but natural, for the earth is in a continual state of stress and strain, many varied and different causes contributing thereto. The term microseisms as here used excludes any deviations of the vertical or movements of the zero position of the pendulum. Some writers have divided microseisms into 'earth tremors' or 'pulsations,' and 'earth pulsations' or 'pulsatory oscillations.' The writer, however, from the seismograms at this station sees no reason for this division, as it is not at all evident from them that the contributory causes, whatever they may be, manifest themselves in such a manner as clearly to differentiate themselves. Furthermore, from the examination of the seismograms the oscillations of the pendulum are excluded; on the one hand, from the frequent change of period on the same seismogram, which would be inadmissible for a pendulum, and on the other hand, if the pendulum were made to oscillate we should expect to see the damping effect in the decrease of amplitude, and a more or less sudden beginning, unless the oscillations of the earth particles themselves were of a period commensurable with that of the pendulum, which, of course, is sometimes the case. It is evident that a photographic registering apparatus with high magnification will record microseisms when a seismograph with mechanical registration will draw only a straight line.

Of the contributing causes to stresses and strains and manifesting themselves as microseisms, we may consider: secular cooling of the earth; unequal heating and the radiation during the day and night; statical effect of atmospheric pressure, areal or local; dynamical effect of atmospheric pressure, areal or local; precipitation, as rain or snow.

The vanishingly small effect of secular cooling, whatever its constants may be, becomes evident from the fact, that, although it is ever present, and its manifestations would be of a constant nature, the recorded microseisms are of the most fluctuating character both in time and magnitude, completely masking the effect of secular cooling. The daily alternations of unequal heating and radiation during the 24 hours are not shown by their effect on microseisms. The case of precipitation is similar in regard to microseisms to the preceding. It may be noted that the stresses set up over large areas, hundreds of miles in extent, by differential loading of rain, is small compared with that of barometric pressure. Taking an area, say of a thousand miles with a rainfall of an inch, which is a pretty heavy rain, and decreasingly distributed, we would have a maximum pressure of a little over one-thirtieth of a pound per square inch, and the rain-pressure diminishing to zero for the edge of the

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area. An average barometric gradient, on the other hand, over such an area would be several times as great, due to a differential atmospheric pressure equivalent to about three-tenths of an inch of the mercurial barometer. The rain-pressure may, however, make itself felt locally, as has been recorded at some stations. The result of a heavy rainfall soon fills the valleys and streams much beyond the direct precipitation on them, so that this loading and bending of the surface may become a measurable quantity by an observing station in the neighbourhood. This effect is, however, one of tilting, of change of vertical or change of pendulum zero and not microseisms, the subject at the moment under discussion.

The effect of difference of atmospheric pressure and of change of atmospheric pressure may be manifested in two ways by the seismograph. We are here dealing with large areas, say 1,000 miles in extent, for local barometric conditions have little or nothing in common with microseisms. In the one case, considering the earth as having an elastic crust, the pier is tilted towards the area of greatest pressure, in consequence of which the pendulum will move in that direction, *i.e.*, its zero line will be displaced. Besides this effect of statical loading, there appears to be no doubt, based on the records here, that vibrations are set up by this statical loading, quite apart from the dynamical effect of change of pressure. In the other case, by change of pressure over a wide area vibrations are set up on the earth's surface, and these may be produced by two allied causes. The one of these is the passage of 'Highs' and 'Lows' over the surface, equivalent to the dragging of a weighted meniscus over the surface, and the other is the winds set up or resulting from the atmospheric gradient due to difference of pressure. The winds would operate more probably by frictional resistance along the surface of the earth rather than by impact or uneven surface or obstructions. In studying various phenomena collectively in an investigation for correlation, considerable restraint must be exercised not to draw conclusions as to cause and effect from a limited number of coincidences, for a conclusion once drawn is apt to become an obsession to the investigator, and he is more or less blinded to facts that do not fit his theory.

In examining the records of microseisms the first question that presents itself is whether the recorded motion is that of the ground or of the pendulum; in the first case the pendulum acts as a steady mass or point, while in the latter case it is set oscillating either by impulses from the ground or by an undulatory movement of the ground. Let us consider the case of microseismic record of the 'sawtooth' type, where we see regular and almost wholly uniform oscillations kept up for hours and longer. If in this case the pendulum actually oscillates it will do so with the period inherent to it. After receiving the first impulse or impact let us suppose it to oscillate. If no further impact were received the oscillations would soon die out and the amplitudes would decrease in the known ratio of the damping coefficient. When a second impulse is given the pendulum will continue its uniform swings, provided the time interval from the preceding impulse is that of the period of the pendulum or a multiple thereof. Were this not the case, interference would occur and would be shown on the record. But such interference is not present in the microseismic records referred to and we must conclude, even admitting that the diagram is a record of the oscillations of the pendulum, that it is in reality only a counterpart of the actual movements of the ground, that is, of horizontal to-and-fro motions of the earth particles. The pendulum can be kept swinging uniformly only by some force acting at intervals of the period of the pendulum. This may occur through the periodic oscillating movements of the earth particles; or the same effect may be produced by rhythmic undulatory movements of the ground. Now, the period of microseisms recorded here lies usually between 5 and 6 seconds, which is also approximately the period of the two pendulums, and the period of the undulatory movements manifested in the 'principal portion' of tectonic earthquakes is 20 seconds or more, so that if we adopt the hypothesis that the microseismic motions are undulatory and not horizontal displacements, we have to explain

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a period only one-quarter of the general period of the earth's crust. The shorter period might perhaps be accounted for by the supposition that a thinner part of the crust of the earth is affected in the microseisms than is involved in the undulatory motion connected with macroseisms. As an analogy we may give the short period of the ripples in water from a breeze, and the much longer one of waves from a storm when a greater depth of water is involved in the motion.

This reasoning does not appear to furnish a conclusive reply to the question whether the microseisms are attributable to the horizontal or to the undulatory movements. However, the consideration of the simultaneous occurrence of microseisms, together with certain atmospheric or barometric conditions leads to the conclusion that microseisms are mostly attributable to horizontal displacements.

Having made daily comparisons with the seismograms, local barograms and weather maps, the following conclusions have been deduced:—It is believed that identical atmospheric conditions prevailing over different parts of the earth's surface will not necessarily produce similar microseisms, as these are affected by the elasticity of the particular area under consideration, also by the geological formation, the presence of well-marked dykes, faults, and by the proximity of large sheets of water or the ocean. One effect of the proximity of the ocean caused by barometric pressure is the change of the level of the water, quite apart from the tides, and this change through loading or unloading along the coast produces a displacement of the pendulum zero, referred to in another place. In the sea, then, we have the dual effect of the direct barometric pressure and the correlated one of displacement of the water, while on land we have only the former. Barometric gradients over the ocean necessarily produce a motion of the water, quite apart from that produced by the winds resulting from the gradients. However, the pressure effect on the ocean bottom remains constant, for any displacement of the water is exactly balanced by the change of atmospheric pressure. Different of course it is on land which suffers the change of barometric pressure.

The feature to strike one most in the above comparisons is that when marked microseisms are present we are almost certain to find that the daily weather map for the morning of the day of record gives for the following 24 hours an area of 'Low' about the Gulf of St. Lawrence. That is, the condition of 'Low' in the gulf precedes the record of marked microseisms. The greater part of the gulf is less than 150 fathoms deep. Through it runs a 'deep' from the mouth of the St. Lawrence (Matane) along the south of Anticosti, passing between Cape Breton and Newfoundland, reaching a depth of 250 fathoms before joining the Atlantic ocean. This deep is over the eastern part of the great St. Lawrence and Champlain Fault, shown on the geological maps, for nearly 700 miles. The waters about Nova Scotia and Newfoundland are all within the 150 fathom line, so that the 'Lows' over the gulf and Sable island are over waters, the greater part of which are less than 150 fathoms deep. The distance from Ottawa to the gulf is about 700 miles, direction east-north-east; and from Ottawa to the nearest broad waters of the Atlantic, off the state of Maine, 300 miles, direction east-south-east.

Next to the presence of a 'Low' in the gulf in importance as a phenomenon accompanying microseisms, we find the isobars which cut the valley of the St. Lawrence (in which lies the great fault) at right angles, so that the gradient is along the St. Lawrence valley, or in general parallel to the Atlantic coast, and to the line of the Alleghany mountains.

Furthermore, it is found that if a 'High' prevails along the south Atlantic coast, northward from Florida the microseisms are intensified.

The passing of 'Highs' and 'Lows' across the coast-line, *i.e.* from land to water, is not found to be marked by the occurrence of microseisms. As the whole atmospheric movement is, for Canada and the United States, from west to east, it is uncommon for a 'High' or 'Low' to cross the coast-line from the Atlantic to the continent.

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It appears that the reversal of the position of 'Low' and 'High' with reference to the gulf for the former is not so closely associated with the subsequent appearance of microseisms as obtains in the case first stated.

When there is a persistence of 'Low' in the gulf and 'High' on the Atlantic coast to the south as indicated, the microseisms set up in the first instance become intensified in amplitude, so that the maximum microseisms are not necessarily coincident with the greatest difference of pressure, or the steepest gradients. It appears that the difference of barometric pressure is in the first instance responsible for the microseisms, and when favourable conditions continue the microseisms will increase in amplitude, although the pressure difference may have decreased. Furthermore, another condition is that the line of 'High'-'Low' preserves its direction along the St. Lawrence valley.

When a 'Low' with even very steep gradients is to the west, say over the lakes, and 'High' on the lower St. Lawrence or gulf, microseisms are generally weak or even absent altogether, although there are exceptions. This is not the case when the 'Low' is to the east, especially when over the gulf. When the 'Low' with steep gradients moves up to Lake Erie by 8 a.m. of the day of the seismogram we may expect to see the beginning of marked microseisms, which increase as the 'Low' moves down the St. Lawrence towards the gulf. From the immediately preceding it is seen that the microseisms give no indication of the approach of a 'Low' or storm centre, but on the contrary, are the result of the passage of a 'Low' and especially of its presence in the gulf. Some investigators believe the microseisms may be the forerunner of coming weather conditions, and hope that this may assist in making forecasts. The seismograms examined here are not very encouraging on that point, the microseisms indicating rather 'that we have had weather, than that we are going to have weather.'

The preceding remarks refer to the microseisms and not to the effect of bending or displacement of the pendulum zero, brought about by unequal pressure over a large area. The writer is not as yet prepared to say whether the approach of a 'Low,' with the consequent lifting or rising of the earth's surface, is a distinctly measurable quantity as registered by our seismograph, for the measurements of the two components of the change of pendulum zero for the year have not yet been tabulated and critically compared with the movements of 'Highs' and 'Lows' in the eastern part of the continent.

By far the large majority of microseisms show themselves by a serrated record, 'sawtooth' type, as I designate them; more rarely are they of the 'spindle' type, where the oscillations or rather the amplitudes rise and fall, increase and decrease, with certain cadence, as in the vibrations of a string between two fixed points. The interval between the maximum amplitudes is very variable, varying from one to several minutes. The rate of increase and decrease of the amplitudes is less than that produced by the damping of the pendulum, so that we can scarcely attribute it to the latter on the supposition that the pendulum itself is set in motion and the oscillation dies down by damping, to be renewed by a fresh impulse. This, however, would preclude a gentle increase; instead there should be a more or less abrupt beginning, which is not the case. Intermittent rhythmic vibrations of the ground, nearly synchronizing with the period of the pendulum, setting the pendulum in motion could produce the phenomenon.

The validity of a supposed relationship between different phenomena, as cause and effect, is tested by predicting the effect when given the cause. This has been done with reference to the existence of a 'Low' in the gulf and a 'High' over the Atlantic coast to the south, or in general by taking the daily weather map with its isobars and from it predicting the resulting microseisms. The result has so far been satisfactory that in the large majority of cases the microseisms have fairly well answered in presence and magnitude the prediction. There are, however, still important out-

standing differences that require further explanation. Just why the 'Low' about the gulf should have such an influence in the production of microseisms is by no means apparent. The two main physical features are the shallow gulf and the St. Lawrence valley in which lies the great St. Lawrence and Champlain Fault, 700 miles long, already referred to. Also there is the generally parallel trend of the Atlantic coast, and that of the Alleghany mountains.

On frequent occasions there is a 'Low' over the gulf, another 'Low' over Arkansas, while one 'High' rests north of Lake Superior and another over Bermuda. When these conditions obtain with steep gradients we are pretty sure to have marked microseisms. The line joining the 'Lows,' then, lies in the St. Lawrence valley, while that of the 'Highs' is at right angles to the former. In this case the maximum strain is along the valley of the St. Lawrence, along the Great Fault, so that from *a priori* reasoning marked microseisms might be expected.

In concluding the present investigation of the well-marked microseisms recorded here, we will repeat, that the presence of a 'Low' over the gulf surrounded by steep or fairly steep gradients on a given morning is indicative of more or less well-marked microseisms following at Ottawa that day.

It has already been stated that the large majority of microseisms have a period of about 5^s with small fluctuations. The cause of the fluctuations is by no means apparent unless it be the varying depth of the earth's surface involved.

On some occasions the period changes to one of about one-half, or about 3^s, showing, however, a transition time during which there is an irregularity and interference, so that their period is unrecognizable. At present no explanation can be offered for this change. When the period is so short, the amplitudes are very minute, although visible on the sheet to the naked eye.

It is found that, broadly speaking, the microseisms are more numerous during the colder season than during the warmer one, and some have sought therein a relationship of cause and effect. In our climate here we have a large range of temperature, during the year 1907-1908, of 127°F. (96° and - 31°F.). During February, when the thermometer reached its lowest and we had some continuously very cold weather, the seismograph showed no evidence thereof. More frequent microseisms might be expected during winter from the fact that the frozen ground better transmits pulsations, and that the act of freezing itself sets up stresses and consequent oscillations. From extreme cold it does not necessarily follow that the ground is frozen to any great depth. During the past winter there was very little frost in the ground, because an early and heavy snowfall, subsequently accumulating to many feet, covered the earth with a mantle that cold could not penetrate.

From examination it is found that the strongest and most numerous microseisms were recorded during the months of January and February last (1909), while during the period September, 1907, to April, 1908, October had the strongest, and the fewest and weakest were during the summer months of July and August, when the atmospheric barometric gradients were very long.

We are led to conclude that strong winds have little effect in causing microseisms by setting up pulsations over large areas of the earth's surface or crust, *i.e.*, the dynamical effect by friction or impact is not the governing factor in the production of microseisms. We are dealing here with the larger effect of strong winds upon large areas and not the local effect upon buildings, which, as is well known, are set in oscillation, and these in turn are communicated to the ground. When the building within which the seismograph is housed is large, the oscillations of the former will be recorded.

When we compare the occurrence of microseisms with the predicted strong winds of the daily forecasts, we find little or no connection between the two phenomena. Considering the two phenomena as independent events, we see that the probability of the simultaneous occurrence of the two events is as great as the actual happening.

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i.e., as far as the observations go there is very little to show any causal relationship between the two.

On the other hand we do find that the winds recorded here by the micro-barograph invariably show themselves on the seismograms, not by microseisms, but by irregular movements, including deviations of the zero line. Microseisms and these latter movements can never be mistaken for earthquake records.

RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N.-S., E.-W. Magnification, 120. Sheet put on each day at about 10. a.m. Standard Time = 15^h G.M.T.

| Date. | N.-S. COMP. | | E.-W. COMP. | | REMARKS. |
|---------|-------------|-----------|-------------|-----------|---|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908. | s. | μ | s. | μ | — |
| Jan. 1. | 5.7 | 8 | 5.8 | 8 | Decreasing towards following morning. |
| " 2. | | | | | Almost wholly quiescent. |
| " 3. | | | | | Almost quiescent. " |
| " 4. | | | | | " " |
| " 5. | 5.5 | 7 | 5.4 | 8 | Increase gradually, reach a maximum about mid-night, then decrease. |
| " 6. | 5.5 | 4 | 5.5 | 4 | |
| " 7. | 5.5 | 4 | 5.5 | 4 | Maximum about 8 a. m., Jan. 8. |
| " 8. | 5.5 | 4 | 5.5 | 4 | |
| " 9. | 5.5 | 4 | 5.5 | 4 | |
| " 10. | 5.6 | | 5.6 | | Small. |
| " 11. | 5.5 | 2 | 5.5 | 2 | |
| " 12. | 5.5 | 4 | 5.5 | 4 | |
| " 13. | 5.5 | 3 | 5.5 | 4 | |
| " 14. | 5.5 | 4 | 5.1 | 4 | Increase about midnight. |
| " 15. | | | | | Present but weak. |
| " 16. | | | | | Slight microseisms scattered throughout. |
| " 17. | | 2 | | 2 | |
| " 18. | | | | | Scarcely any. |
| " 19. | | | | | " " |
| " 20. | 5.5 | 2 | 5.5 | 2 | |
| " 21. | 5.5 | 2 | 5.5 | 2 | |
| " 22. | 3.0 | | | | |
| " 23. | 5.3 | 4 | 5.5 | 4 | |
| " 24. | 5.5 | 7 | 5.5 | 7 | Two hours at beginning and end of sheet weakest. |
| " 25. | 5.5 | | 5.7 | | Decreasing. |
| " 26. | | | | | Small, of usual saw-tooth type, not so well expressed by N-S component. |
| " 27. | 5.5 | 4 | 5.5 | 4 | |
| " 28. | | | | | Present throughout. |
| " 29. | | | | | " " |
| " 30. | | 2 | | 2 | |
| " 31. | | | | | Slight throughout. |
| Feb. 1. | | 6 | | 6 | Earthquake occurs, microseisms after quake. |
| " 2. | 5.7 | 6 | 6.3 | 6 | |
| " 3. | | | | | Not so strong as yesterday. |
| " 4. | | | | | Scarcely any. |
| " 5. | | | | | Weak. |
| " 6. | | | | | " |
| " 7. | 5.5 | 2 | 6.0 | 2 | |
| " 8. | | | | | Small. |
| " 9. | | | | | Very slight. |
| " 10. | | | | | Scarcely any. |
| " 11. | | | | | " " |
| " 12. | | | | | Very few and weak. |
| " 13. | | | | | Small and fairly evenly distributed. |
| " 14. | | | | | Very few. |
| " 15. | 5.4 | 3 | 6.3 | 4 | |
| " 16. | 5.3 | 3 | 6.6 | 5 | |
| " 17. | 5.5 | 3 | 6.3 | 3 | |
| " 18. | | | | | Scarcely any. |

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RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N.-S., E.-W. Magnification, 120. Sheet put on each day at about 10 a.m. Standard Time = 15^h G.M.T.—*Con.*

| Date. | N-S COMP. | | E-W. COMP. | | REMARKS. |
|----------|-----------|-----------|------------|-----------|--|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908, | s. | μ | s. | μ | |
| Feb. 19. | | | | | Very minute, increase after 3 a. m. |
| 20. | 5.7 | | 6.4 | 4 | Fairly strong by E-W component. |
| 21. | 6.0 | | 6.8 | 6 | |
| 22. | 6.0 | 3 | 6.5 | 4 | |
| 23. | | | | | Very weak. |
| 24. | | | | | Weak. |
| 25. | | | | | Practically quiescent. |
| 26. | | | | | Very minute. |
| 27. | | | | | Small. |
| 28. | | | | | Very weak. |
| 29. | | | | | Slight traces. |
| March 1. | | | | | " " |
| 2. | | | | | Very slight traces. |
| 3. | 3.0 | | 3.0 | | Very weak. |
| 4. | | | | | Apparently quiescent. |
| 5. | | | | | Almost perfectly quiescent. |
| 6. | 5.5 | 3 | 6.0 | 5 | Decrease after 6 p.m. |
| 7. | | | | | Very slight. |
| 8. | | | | | " " |
| 9. | | | | | Almost quiescent till about 3 a.m., when microseisms set in, reading 3 μ . |
| 10. | 5.7 | 1 | 6.9 | 4 | |
| 11. | | 1 | | 2 | |
| 12. | | 1 | | 1 | |
| 13. | | | | | Very slight. |
| 14. | | | | | " " |
| 15. | | | | | " " |
| 16. | | | | | Practically quiescent. |
| 17. | | | | | Quiescent. |
| 18. | | | | | Very minute. |
| 19. | | | | | " " |
| 20. | | | | | Minute. |
| 21. | 5.7 | 2 | 6.3 | 2 | Small. |
| 22. | | | | | Very slight. |
| 23. | | | | | " " |
| 24. | | | | | Small. |
| 25. | | 4 | | 4 | Decrease after 7 p.m. |
| 26. | | | | | Small. Continue between the two earthquake records of Chilapa, Mexico. |
| 27. | | | | | Very minute. |
| 28. | | 2 | | 2 | Minute. |
| 29. | | | | | " |
| 30. | 4.0 | 2 | | | |
| 31. | | | | 3 | Strongest during night. |
| April 1. | 4.6 | 4 | 4.8 | 2 | Increase after 6 p.m. |
| 2. | | | | | Less strong. |
| 3. | 5.2 | 5 | 5.0 | 5 | |
| 4. | 5.7 | 6 | 7.5 | 6 | |
| 5. | | 3 | | 3 | Gradually decreasing. |
| 6. | | | | | Minute. |
| 7. | | | | | Very minute. |
| 8. | | | | | Minute. |
| 9. | 3.5 | 2 | 3.5 | 2 | |
| 10. | 5.2 | 4 | 6.3 | 2 | |
| 11. | 5.5 | 4 | 5.0 | 3 | |
| 12. | 5.7 | 6 | 6.2 | 4 | |
| 13. | 5.7 | 7 | 6.0 | 5 | |
| 14. | 5.3 | 4 | 6.0 | 3 | Decreasing. |
| 15. | 5.3 | | 7.5 | | By following morning period for both 3.7. |
| 16. | 4.2 | 3 | 4.1 | 2 | Decrease. |
| 17. | 5.5 | 4 | 5.5 | 4 | |
| 18. | 6.0 | 4 | 7.3 | 5 | |

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RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N.-S., E.-W. Magnification, 120. Sheet put on each day at about 10 am. Standard Time = 15^h G.M.T.—*Con.*

| Date. | N.-S. Comp. | | E. W. Comp. | | REMARKS. |
|----------|-------------|-----------|-------------|-----------|--|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908. | s. | μ | s. | μ | |
| Apr. 19. | | | | | Minute, increase after 6 p.m. |
| " 20. | | 4 | | 3 | |
| " 21. | 5.3 | 4 | 5.4 | 3 | |
| " 22. | 5.2 | 3 | 5.7 | 2 | |
| " 23. | 5.5 | | 5.5 | | Very minute, and decreasing. |
| " 24. | 5.0 | 2 | 5.0 | 2 | Quiescent after noon. |
| " 25. | | | | | Almost quiescent. |
| " 26. | | 1 | | 1 | Small. |
| " 27. | | 2 | | 2 | Stronger after 6 a. m. |
| " 28. | 6.3 | 4 | 7.5 | 5 | |
| " 29. | 6.6 | 5 | 7.5 | 6 | |
| " 30. | | 2 | | 3 | |
| May 1. | | 2 | | 2 | |
| " 2. | 5.3 | 3 | 6.0 | 2 | |
| " 3. | 5.3 | 5 | 6.3 | 4 | |
| " 4. | | 5 | | 4 | Strongest during night. |
| " 5. | 5.7 | 6 | 6.0 | 5 | Decrease after 1 a. m. |
| " 6. | 5.5 | 2 | 6.0 | 2 | |
| " 7. | 5.5 | 3 | 6.0 | 2 | |
| " 8. | 4.3 | | 5.0 | | Minute. |
| " 9. | 5.5 | 3 | 6.0 | 2 | |
| " 10. | 5.5 | 4 | 5.7 | 3 | |
| " 11. | | 2 | | 1 | Decreasing. |
| " 12. | 3.5 | 1 | 7.0 | 4 | |
| " 13. | 4.0 | | | | Very minute. |
| " 14. | 4.3 | | | | " |
| " 15. | | | | | " |
| " 16. | 5.2 | 1 | | | Very small. |
| " 17. | | | | | Almost quiescent. |
| " 18. | | | | | " " |
| " 19. | | | | | " " |
| " 20. | | | | | " " |
| " 21. | | | | | Almost wholly quiescent. |
| " 22. | | | | | Practically quiescent. |
| " 23. | | | 7.0 | | Almost quiescent. |
| " 24. | | | | | Quiescent. |
| " 25. | | | | | Almost quiescent. |
| " 26. | | | | | Quiescent. |
| " 27. | | | | | Slight traces. |
| " 28. | | | | | Quiescent. |
| " 29. | 2.7 | | 4.6 | | Very minute. |
| " 30. | 2.7 | | 4.3 | | " |
| " 31. | | | | | Apparently quiescent, but shows very minute and rapid oscillations |
| June 1. | | | | | " " |
| " 2. | | | | | Practically quiescent. |
| " 3. | | | 7.0 | 2 | |
| " 4. | | | | | Very small. |
| " 5. | | | | | Practically quiescent. |
| " 6. | | | | | " " |
| " 7. | | | | | Faintest traces. |
| " 8. | | | | | " |
| " 9. | | | | | " |
| " 10. | | | | | Practically quiescent. |
| " 11. | | | | | Perfectly quiescent. |
| " 12. | | | | | Quiescent. |
| " 13. | | | | | Practically quiescent. |
| " 14. | | | | | Quiescent. |
| " 15. | | | | | Small, scattered. |
| " 16. | | | | | Small. |
| " 17. | | | | | Very minute. |
| " 18. | 5.5 | 1 | | | Decrease after midnight. |

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RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N-S., E-W. Magnification, 120. Sheet put on each day at about 10 a.m. Standard Time = 15^b G.M.T.—*Con.*

| Date. | N-S. COMP. | | E-W. COMP. | | REMARKS. |
|----------|------------|-----------|------------|-----------|--|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908. | s. | μ | s. | μ | |
| June 19. | | | | | Small. |
| " 20. | | | | | Nearly quiescent. |
| " 21. | | | | | Very minute. |
| " 22. | | | | | A few very minute shown by N-S component. |
| " 23. | | | | | A few scattered shown by N-S component. |
| " 24. | 4.4 | 1 | | | Strongest about 4 p. m. |
| " 25. | | | | | Practically quiescent. |
| " 26. | | | | | " " |
| " 27. | | | | | " " |
| " 28. | | | | | Practically quiescent. |
| " 29. | | | | | " " |
| " 30. | | | | | Very minute by N-S component. |
| July 1. | | | | | Practically quiescent. |
| " 2. | | | | | " " |
| " 3. | | | | | Quiescent. |
| " 4. | | | | | " " |
| " 5. | | | | | Minute. |
| " 6. | | | | | Quiescent. |
| " 7. | | | | | Almost quiescent, some minute between 2 and 4 a.m. (July 8). |
| " 8. | | | | | Quiescent. |
| " 9. | | | | | Very minute, mostly shown by N-S component. |
| " 10. | | | | | Practically quiescent. |
| " 11. | | | | | Quiescent. |
| " 12. | | | | | " " |
| " 13. | | | | | " " |
| " 14. | | | | | " " |
| " 15. | | | | | " " |
| " 16. | | | | | " , a few very minute. |
| " 17. | | | | | Very minute throughout, more distinct by N-S component. |
| " 18. | | | | | Very minute. |
| " 19. | | | | | Practically quiescent. |
| " 20. | | | | | Quiescent. |
| " 21. | | | | | " " |
| " 22. | | | | | " " |
| " 23. | | | | | " " |
| " 24. | | | | | " " |
| " 25. | | | | | " until about 8 a. m. (July 26) when minute micros. appear and increase. |
| " 26. | 5.2 | 4 | 5.2 | 4 | First typical "sawtooth" micros. for months. Strongest between 9 p.m. and 3 a.m. Period N-S component pendulum ϕ .1, E-W component pendulum 10° l. |
| " 27. | 5.5 | 3 | 6.0 | 3 | Decrease, disappear after 12 p.m. |
| " 28. | | | | | Practically quiescent. |
| " 29. | | | | | Quiescent. |
| " 30. | | 1 | | 1 | Very minute. |
| " 31. | | | | | Almost quiescent. |
| Aug. 1. | 5.0 | 4 | 5.0 | 4 | Low moving up Atlantic coast from Hatteras. |
| " 2. | 5.0 | 4 | 5.0 | 4 | Little stronger than yesterday. Maximum about midnight. |
| " 3. | 5.0 | 3 | 5.0 | 3 | |
| " 4. | | 2 | | 2 | |
| " 5. | | | | | Practically quiescent. |
| " 6. | | | | | Quiescent. |
| " 7. | | | | | " " |
| " 8. | | | | | " " |
| " 9. | | 1 | | 1 | Very minute. |
| " 10. | | | | | " " |
| " 11. | | | | | " , shown best by N-S. component. |

SESSIONAL PAPER No. 25a

RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N.-S., E.-W. Magnification, 120. Sheet put on each day at about 10 a.m. Standard Time = 15^h G.M.T.—*Con.*

| Date. | N.-S. Comp. | | E.-W. Comp. | | REMARKS. |
|---------|-------------|-----------|-------------|-----------|---|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908. | s. | μ | s. | μ | |
| Aug. 12 | | | | | Practically quiescent. |
| " 13 | | | | | Quiescent. |
| " 14 | | | | | " |
| " 15 | | 1 | | 1 | |
| " 16 | | 1 | | 1 | Not continuous. |
| " 17 | | | | | Almost quiescent. |
| " 18 | 4.5 | | | | Very minute. |
| " 19 | | | | | " |
| " 20 | | 1 | | 1 | |
| " 21 | | 2 | | 2 | |
| " 22 | | 2 | | 2 | Strongest in forenoon. |
| " 23 | | 2 | | 2 | " about 3 a.m. (Aug. 24). |
| " 24 | | | | | Very small. |
| " 25 | | | | | Minute. |
| " 26 | 3.7 | 1 | 3.7 | 1 | Quiescent till about 2 a.m. (Aug. 27), then small. |
| " 27 | 5.1 | 5 | 5.1 | 4 | Low moving up Atlantic coast from Hatteras. |
| " 28 | 5.0 | 1 | 5.0 | 1 | Decrease after 8 p.m. |
| " 29 | | | | | Very minute, and decrease. |
| " 30 | | | | | Practically quiescent. |
| " 31 | | | | | " " |
| Sep. 1 | | | | | Almost quiescent. |
| " 2 | 3.8 | 1 | 3.8 | 1 | Minute. |
| " 3 | 5.0 | | 5.0 | | A little stronger than yesterday. |
| " 4 | | | | | Practically quiescent. |
| " 5 | | | | | " " |
| " 6 | | | | | Practically quiescent, save for fluctuations, not micros. caused by gusty wind. |
| " 7 | 5.5 | 2 | 6.0 | 1 | |
| " 8 | 5.0 | | 5.0 | | |
| " 9 | 5.0 | 1 | 5.0 | 1 | Decreasing after midnight. |
| " 10 | 5.0 | 1 | 5.0 | 1 | |
| " 11 | 5.0 | | 5.0 | | Very small. |
| " 12 | 6.0 | 1 | 7.5 | 2 | Towards evening micros. appear, increase to midnight, then decrease. |
| " 13 | | | | | Minute. |
| " 14 | 4.7 | 1 | 4.9 | 1 | Minute, increase. |
| " 15 | 5.5 | 2 | 5.5 | 2 | |
| " 16 | 5.6 | 3 | 6.4 | 4 | Maximum about 10 p.m. |
| " 17 | 4.5 | 2 | 5.8 | 3 | |
| " 18 | 5.7 | 3 | 6.3 | 4 | |
| " 19 | 5.9 | 4 | 6.6 | 5 | |
| " 20 | 4.7 | 3 | 5.5 | 4 | |
| " 21 | 5.4 | 2 | 6.8 | 3 | |
| " 22 | 6.1 | 1 | 6.8 | 2 | |
| " 23 | 5.0 | 1 | 5.7 | 1 | |
| " 24 | | | 7.5 | 1 | Almost wholly quiescent, here and there micros. |
| " 25 | | | 7.0 | 1 | |
| " 26 | 5.6 | 1 | 7.5 | 1 | |
| " 27 | 5.5 | | 5.7 | | Small; N-S component the stronger, being reverse of what it has been lately. |
| " 28 | 5.5 | 1 | 5.7 | 1 | |
| " 29 | 5.0 | 2 | 5.0 | 1 | |
| " 30 | 5.1 | 2 | 6.2 | 1 | |
| Oct. 1 | 5.3 | 1 | 5.1 | 1 | |
| " 2 | 4.0 | 1 | 4-10 | 3 | After 1 a.m. (Oct. 3) periods lengthen, and intensity increases. |
| " 3 | 4.5 | 4 | 7.5 4.7 | 4 | Increase after 9 p.m. Period of E-W component becomes shorter. |
| " 4 | 5.3 | 3 | 5.5 | 2 | Decreasing. |
| " 5 | 5.4 | 2 | 5.5 | 1 | |
| " 6 | | | | | Minute. |

9-10 EDWARD VII., A. 1910

RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N.-S., E.-W. Magnification, 120. Sheet put on each day at about 10 a.m. Standard Time = 15^h G.M.T.—*Con.*

| Date. | N.-S. COMP. | | E.-W. COMP. | | REMARKS. |
|--------|-------------|-----------|-------------|-----------|--|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908. | s. | μ | s. | μ | |
| Oct. 7 | 4.9 | 1 | 4.9 | 1 | |
| " 8 | 4.8 | 2 | 5.1 | 2 | Strongest about 8 p.m. |
| " 9 | 5.2 | 2 | 5.4 | 2 | Strongest about midnight. |
| " 10 | 5.3 | 2 | 5.8 | 2 | Strongest between 8 p.m. and 2 a.m. |
| " 11 | 4.6 | | 5.0 | | Very small, better expressed by N.-S. component. |
| " 12 | | | | | Small and well marked. |
| " 13 | 5.3 | 2 | 5.2 | 2 | |
| " 14 | 5.6 | 3 | 5.7 | 3 | Strongest about 9 p.m. |
| " 15 | 5.2 | 1 | 6.8 | 1 | Almost disappear by following morning. |
| " 16 | | | | | Almost quiescent. |
| " 17 | 6.4 | 1 | 6.7 | 2 | Almost quiescent till about 9 p.m. then become pretty well marked. |
| " 18 | 6.5 | 1 | 7.0 | 1 | |
| " 19 | | | | | Very minute. |
| " 20 | 4.9 | 1 | 6.7 | 1 | Almost quiescent. |
| " 21 | 6.0 | 3 | 6.6 | 4 | Minute till 9 p.m., then increase. |
| " 22 | 6.3 | 3 | 6.8 | 5 | Decrease after 8 p.m. |
| " 23 | 5.1 | 1 | 7.8 | 1 | |
| " 24 | 5.1 | 2 | 6.9 | 2 | |
| " 25 | 5.4 | 2 | 5.5 | 2 | |
| " 26 | 5.3 | 1 | 5.6 | 1 | Decrease after 2 a.m., (Oct. 27). |
| " 27 | 5.4 | 1 | 6.1 | 1 | |
| " 28 | 5.1 | 1 | 6.0 | 1 | Scattered throughout, not continuous. |
| " 29 | 4.6 | 4 | 4.3 | 3 | Increase after 2 a.m., (Oct. 30). |
| " 30 | 4.7 | 3 | 4.5 | 2 | |
| " 31 | 5.4 | 6 | 5.4 | 3 | Begin small. After 5 a.m., (Nov. 1st), become very marked. |
| Nov. 1 | 5.6 | 6 | 5.8 | 4 | "Sawtooth" type, very few of spindle form. |
| " 2 | 5.5 | 4 | 5.4 | 3 | |
| " 3 | 5.4 | 5 | 5.8 | 3 | |
| " 4 | 5.4 | 4 | 5.5 | 2 | |
| " 5 | 5.0 | 4 | 4.9 | 2 | Strongest during the night. |
| " 6 | 5.8 | 10 | 6.6 | 6 | |
| " 7 | 5.8 | 6 | 5.9 | 4 | |
| " 8 | 5.7 | 3 | 5.8 | 2 | |
| " 9 | 5.3 | 2 | 5.3 | 1 | |
| " 10 | 5.0 | 1 | 5.9 | 1 | |
| " 11 | 4.8 | 1 | 6.9 | 1 | |
| " 12 | 4.9 | 5 | 5.4 | 3 | Fairly quiescent till midnight, when micros set in and increase in intensity. |
| " 13 | 5.2 | 5 | 5.7 | 4 | |
| " 14 | 5.4 | 2 | 5.8 | 2 | After 2 a.m., period changes markedly by decreasing to 4". |
| " 15 | 4.8 | 2 | 4.6 | 2 | |
| " 16 | 4.8 | 3 | 5.3 | 2 | |
| " 17 | 4.5 | 1 | 5.5 | 1 | |
| " 18 | 4.8 | 4 | 5.0 | 3 | Increase after 7 p.m. |
| " 19 | 4.3 | 4 | 4.4 | 3 | Maximum about 7 p.m. |
| " 20 | 5.0 | 2 | 8.3 | 1 | |
| " 21 | 5.0 | 2 | 5.0 | 1 | |
| " 22 | 4.0 | 2 | 4.0 | 1 | |
| " 23 | | | | | Scarcely a trace. |
| " 24 | 5.0 | 1 | | | Almost quiescent. |
| " 25 | 5.0 | 1 | | | " |
| " 26 | 5.7 | 1 | 7.0 | 1 | |
| " 27 | 5.2 | 2 | 7.2 | 1 | |
| " 28 | 5.0 | 3 | 5.0 | 2 | |
| " 29 | 5.6 | 3 | 5.6 | 2 | Decrease. |
| " 30 | 5.2 | 2 | 5.3 | 1 | |
| Dec. 1 | | | | | Very windy, shown by irregularity of zero line. New steel point for E.-W. component. |
| " 2 | 5.1 | 3 | 4.5 | 3 | Begin small, become well-marked by following morning. |

SESSIONAL PAPER No. 25a

RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N.-S., E.-W. Magnification, 120. Sheet put on each day at about 10 a.m. Standard Time = 15^h G.M.T.—*Con.*

| Date. | N.-S. COMP. | | E.-W. COMP. | | REMARKS. |
|--------|-------------|-----------|-------------|-----------|--|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908. | s. | μ | s. | μ | |
| Dec. 3 | 5.4 | 3 | 4.3 | 4 | |
| " 4 | 5.1 | 2 | 4.5 | 2 | |
| " 5 | 5.1 | 3 | 4.5 | 5 | Begin small. |
| " 6 | 5.1 | 4 | 4.5 | 6 | |
| " 7 | 5.1 | 3 | 4.3 | 8 | |
| " 8 | 5.2 | 5 | 4.6 | 9 | |
| " 9 | 5.1 | 3 | 4.3 | 4 | |
| " 10 | 5.3 | 3 | 4.6 | 4 | |
| " 11 | 5.8 | 3 | 4.5 | 4 | Strongest about 7 p.m. |
| " 12 | 5.6 | 4 | 4.6 | 5 | |
| " 13 | 5.5 | 5 | 4.4 | 5 | |
| " 14 | 5.3 | 3 | 4.6 | 5 | |
| " 15 | 5.6 | 4 | 4.7 | 4 | |
| " 16 | 5.3 | 3 | 4.6 | 4 | |
| " 17 | 5.3 | 3 | 4.5 | 5 | |
| " 18 | 5.1 | 3 | 4.4 | 5 | |
| " 19 | 5.2 | 3 | 6.5 | 6 | |
| " 20 | 6.2 | 2 | 6.6 | 5 | |
| " 21 | 4.9 | 1 | 6.6 | 2 | |
| " 22 | 5.1 | 1 | 5.6 | 4 | |
| " 23 | 5.5 | 4 | 6.6 | 7 | |
| " 24 | 5.6 | 2 | 6.3 | 4 | |
| " 25 | 5.6 | 1 | 6.3 | 3 | |
| " 26 | 5.5 | 4 | 6.8 | 7 | Strongest between 5 and 12 p.m. |
| " 27 | 5.4 | 4 | 6.1 | 7 | |
| " 28 | 5.6 | 4 | 6.2 | 5 | No difference of micros. before and after the earthquake (Messina). |
| " 29 | 4.3 | 2 | 4.7 | 4 | |
| " 30 | 5.4 | 1 | 6.4 | 2 | |
| " 31 | | | | | Small to minute. |
| 1909. | | | | | |
| Jan. 1 | 5.5 | 2 | 5.9 | 3 | |
| " 2 | 5.1 | 1 | 5.8 | 2 | |
| " 3 | 5.0 | 1 | 5.4 | 1 | Almost quiescent. |
| " 4 | 5.0 | 1 | 6.3 | 1 | " " |
| " 5 | 5.3 | 1 | 6.5 | 2 | |
| " 6 | 5.3 | 2 | 6.0 | 3 | Increasing. |
| " 7 | 4.9 | 2 | 6.6 | 4 | |
| " 8 | 4.9 | — | 6.4 | 1 | Almost quiescent. |
| " 9 | | | | | " perfectly quiescent. |
| " 10 | 5.3 | 1 | 6.5 | 2 | |
| " 11 | 5.0 | 1 | 6.5 | 2 | |
| " 12 | 5.3 | 1 | 8.6 | 2 | |
| " 13 | 5.1 | 1 | 6.6 | 2 | |
| " 14 | 5.4 | — | 6.6 | — | Almost perfectly quiescent. |
| " 15 | 4.7 | 1 | 5.7 | 2 | |
| " 16 | 5.3 | 2 | 6.7 | 5 | |
| " 17 | | | 7.0 | 5 | Wind effect shown by irregularities of zero line, N-S component off. |
| " 18 | | | 6.6 | 8 | Maximum between 5 and 9 a.m. (January 19). N-S component off. |
| " 19 | | | | 12 | Strongest in a long time. |
| " 20 | 5.9 | 4 | 6.9 | 7 | |
| " 21 | 5.4 | 2 | 6.0 | 3 | Almost cease after 5 p.m. |
| " 22 | 5.8 | 1 | 6.7 | 1 | Fairly quiescent. |
| " 23 | 5.7 | 1 | 5.9 | 1 | Scattered, not continuous. |
| " 24 | 6.0 | 2 | 6.1 | 2 | |
| " 25 | 6.0 | 1 | 6.0 | 1 | Wind makes zero line irregular. |
| " 26 | 4.5 | 3 | 4.5 | 3 | |
| " 27 | 5.6 | 5 | 6.5 | 6 | |

9-10 EDWARD VII., A. 1910

RECORD of Microseisms for the period January 1, 1908, to March 31, 1909. Two Bosch photographic seismographs, mounted N.-S., E.-W. Magnification, 120. Sheet put on each day at about 10 a.m. Standard Time = 15^h G.M.T.—*Con.*

| Date. | N.-S. COMP. | | E.-W. COMP. | | REMARKS. |
|---------|-------------|-----------|-------------|-----------|--|
| | Period. | Max. Amp. | Period. | Max. Amp. | |
| 1908. | s. | μ | s. | μ | |
| Jan. 28 | 5.8 | 5 | 6.8 | 7 | |
| " 29 | 6.6 | 5 | 6.8 | 8 | |
| " 30 | 6.0 | 5 | 6.7 | 6 | |
| " 31 | 5.3 | 2 | 6.6 | 3 | |
| Feb. 1 | 5.5 | 2 | 6.4 | 4 | |
| " 2 | 5.4 | 1 | 6.2 | 2 | Decreasing. |
| " 3 | 5.2 | 1 | 5.8 | 1 | Almost quiescent. |
| " 4 | 5.2 | 1 | 5.2 | 1 | " " |
| " 5 | 5.2 | 1 | 5.4 | 1 | Minute. |
| " 6 | 3.5 | 1 | 4.6 | 1 | |
| " 7 | 5.1 | 2 | 5.1 | 2 | |
| " 8 | 5.4 | 5 | 5.6 | 5 | Decrease after 8 p.m. |
| " 9 | 5.5 | 6 | 6.2 | 8 | Increasing. |
| " 10 | | | | | No light. |
| " 11 | 5.7 | 2 | 6.7 | 2 | Small. |
| " 12 | 5.4 | 1 | 5.9 | 1 | |
| " 13 | 4.5 | 1 | 4.5 | 1 | Minute. |
| " 14 | 4.5 | 1 | 4.5 | 1 | Very small. |
| " 15 | 6.2 | 1 | 6.8 | 2 | Decreasing. |
| " 16 | 3.7 | 1 | 3.7 | 1 | Periods decrease after 7 p.m. |
| " 17 | 4.4 | 2 | 6.6 | 2 | |
| " 18 | 5.4 | 2 | 6.5 | 3 | Begin small, but increase, particularly after 5 a.m. |
| " 19 | 5.9 | 3 | 6.8 | 5 | (Feb. 19). |
| " 20 | 5.1 | 2 | 6.4 | 3 | |
| " 21 | 5.7 | 2 | 6.4 | 4 | In general not as strong as yesterday. |
| " 22 | 5.7 | 2 | 6.2 | 3 | |
| " 23 | 5.6 | 1 | 6.2 | 1 | Small. |
| " 24 | 5.3 | 1 | 6.2 | 1 | Wind effect shown by irregularity of zero line. |
| " 25 | 5.6 | 5 | 6.3 | 6 | Wind effect shown by irregularity of zero line. After 4 30 p.m., micros. well-marked. |
| " 26 | 5.8 | 5 | 6.7 | 7 | |
| " 27 | 6.1 | 4 | 6.9 | 8 | Decrease after 6 p.m. |
| " 28 | 5.6 | 2 | 6.3 | 3 | Decreasing. |
| March 1 | 5.3 | 1 | 5.9 | 2 | |
| " 2 | 5.5 | 1 | 6.5 | 2 | |
| " 3 | 4.8 | 6 | 4.6 | 4 | Small but after 5 a.m. (March 4) strong set in. |
| " 4 | 4.9 | 4 | 5.0 | 3 | |
| " 5 | 5.4 | 4 | 5.7 | 4 | |
| " 6 | 5.4 | 2 | 6.2 | 2 | Gradual decrease. |
| " 7 | 5.8 | 2 | 6.4 | 4 | " increase. |
| " 8 | 5.7 | 3 | 6.3 | 6 | |
| " 9 | 5.8 | 2 | 6.3 | 4 | Decrease to small and minute. |
| " 10 | 5.3 | 1 | 5.5 | 1 | |
| " 11 | 5.2 | 1 | 5.8 | 1 | Wind effect shown as heretofore. |
| " 12 | 5.6 | 1 | 6.0 | 1 | |
| " 13 | 5.3 | 1 | 6.2 | 1 | |
| " 14 | 5.2 | 1 | 6.4 | 1 | |
| " 15 | 5.2 | 1 | 6.4 | 1 | |
| " 16 | 5.4 | 2 | 6.1 | 2 | |
| " 17 | 5.7 | 2 | 6.4 | 3 | |
| " 18 | 5.5 | 3 | 6.6 | 5 | Increases to well marked. |
| " 19 | 5.8 | 3 | 6.5 | 5 | Maximum between 8 & 12 p.m. |
| " 20 | 5.9 | 4 | 7.0 | 6 | Decreasing. |
| " 21 | 5.7 | 3 | 6.7 | 4 | |
| " 22 | 5.8 | 3 | 6.6 | 5 | |
| " 23 | 5.5 | 3 | 6.8 | 4 | Strongest between 6 & 9 p.m. |
| " 24 | 5.3 | 2 | 6.4 | 2 | |
| " 25 | 5.3 | 1 | 5.8 | 1 | Snow storm shows irregularity of zero line. |
| " 26 | 5.4 | 2 | 6.6 | 3 | |
| " 27 | 5.5 | 3 | 6.5 | 4 | |
| " 28 | 5.4 | 3 | 6.5 | 3 | |
| " 29 | 5.2 | 3 | 6.2 | 3 | |
| " 30 | 5.3 | 2 | 6.2 | 2 | |
| " 31 | 5.4 | 1 | 6.4 | 1 | |

SESSIONAL PAPER No. 25a

A table was compiled for the official year April 1, 1908, to April 1, 1909, in which were given day by day for every twelve hours, 8 a.m. and 8 p.m. eastern standard time, the position and pressure of the Low, as shown by the charts of the 'Tracks of Centres of Low Areas' published in the United States Monthly Weather Review. In an adjoining column was entered the occurrence and intensity of microseisms on the respective date. The object was to determine if possible the relationship between the existing Low at any particular time and place with the prevailing microseisms at Ottawa. Unfortunately for the purpose in hand the published track of Lows ends generally at the gulf, sometimes near its west coast, and less frequently in Newfoundland, so that the presence of a Low immediately east of the gulf, and which probably is the cause of many of the microseisms, is not noted, with the result that the Low in the west with which the microseisms are bracketed, being the only Low on the chart, is asked, so to speak, to account for the microseisms, when in reality they have nothing to do with it, but are due to the uncharted Low of the vicinity of the gulf or Newfoundland. The comparison between Lows and microseisms as above was consequently very misleading. It resulted in frequently having strong microseisms associated with a Low in the gulf, which is generally the case, but the next day the microseisms would probably persist, while the Low moved eastward beyond the sphere of the chart, yet they would in the table appear opposite to a Low far in the west, with which it could not possibly be related. I have therefore omitted this tabulation.

The following table has been compiled from the charts 'Tracks of centres of Low Areas,' published in the Washington 'Monthly Weather Review.' The object was to see whether the dynamical effect of the daily movement of the Lows across the continent was manifested by microseisms, that is, whether the apparent velocity of translation of the Low produced microseisms, and whether the intensity of the latter was a function of the velocity. The consideration here is independent of the steepness of gradients accompanying a Low. We may have a Low persistent or stationary for some time and this would hence not belong to the above investigation. That same Low may however be surrounded by steep gradients, which, in turn, as shown elsewhere, will be conducive to the appearance of microseisms. The rapidity with which a Low travels across the continent, from west to east, is quite independent of the gradients or isobars that accompany it. In the table, the first column gives the number of the Low for the respective month; the next column headed 'Beginning' gives the day of the month, forenoon—a—at 8 a.m.) or afternoon—p—(8 p.m.) with barometer reading, when the Low began its course; the third column 'Ending' gives the date, forenoon or afternoon, with pressure when the Low ended or rather left the continent. The fourth column, 'Duration,' is the difference between the second and third, expressed in days. The fifth column, 'Distance,' gives the length of the track or path followed by the Low, and was obtained by following on the map with a graduated measuring wheel, adapted for the purpose, the path of the Low from beginning to end across the continent. The odd miles in the distances must not be taken too seriously, they simply show the multiplication of a constant factor by the revolutions and part of a revolution of the wheel measuring the track. The sixth column which gives the division of 'Distance' by 'Duration,' expresses the apparent average daily velocity of the Low across the continent. Finally, the last column shows where the Low was lost to observation or ended as far as the continent is concerned. 'Gulf' refers to the waters and surroundings of the Gulf of St. Lawrence, while 'Atlantic' refers to the ocean along the continent from Maine to Florida. 'Interior' indicates that either the Low disappeared as such in the interior, or was lost to observation in northeastern Canada:—

9-10 EDWARD VII., A. 1910

APRIL, 1908.

| No. | Beginning. | | Ending. | | Duration | Distance. | Apparent average daily velocity. | Disappearance. |
|------|------------|-------|---------|-------|----------|-----------|---|----------------|
| | in. | | in. | | days. | miles. | miles. | |
| I | 1a | 29.70 | 3a | 29.04 | 2.0 | 1,700 | 850 | Gulf. |
| II | 3a | 29.32 | 6a | 29.64 | 3.0 | 2,480 | 827 | " |
| III | 6p | 29.56 | 9a | 29.18 | 2.5 | 2,340 | 936 | " |
| IV | 8p | 29.60 | 12a | 28.88 | 3.5 | 2,340 | 668 | " |
| V | 13a | 29.64 | 16a | 29.58 | 3.0 | 2,560 | 853 | " |
| VI | 15p | 29.68 | 19p | 29.14 | 4.0 | 3,024 | 756 | " |
| VII | 17a | 29.44 | 19p | 29.14 | 2.5 | 2,832 | 1,133 | " |
| VIII | 20p | 29.58 | 29a | 29.72 | 8.5 | 4,576 | 538 | " |
| IX | 21p | 29.46 | 29a | 29.72 | 7.5 | 4,016 | 535 | " |
| X | 21p | 29.90 | 23p | 29.78 | 2.0 | 896 | 448 | Atlantic. |
| XI | 25p | 29.42 | 29a | 29.72 | 3.5 | 2,128 | 608 | Gulf. |
| XII | 25p | 29.36 | 29a | 29.72 | 3.5 | 2,048 | 586 | " |
| XIII | 27p | 29.70 | 30p | 29.24 | 3.0 | 2,704 | 901 | Atlantic. |
| | | | | | | Mean | 742 | |

MAY, 1908.

| | | | | | | | | |
|------|-----|-------|-----|-------|-----|-------|-----|-----------|
| I | 1a | 29.68 | 1p | 29.40 | 0.5 | 160 | 320 | Gulf. |
| II | 1a | 29.64 | 3a | 29.36 | 2.0 | 1,168 | 584 | " |
| III | 2a | 29.35 | 10a | 29.32 | 8.0 | 3,536 | 442 | " |
| IV | 6p | 29.54 | 9a | 29.80 | 2.5 | 656 | 262 | Interior. |
| V | 7a | 29.60 | 8p | 29.60 | 1.5 | 976 | 651 | Gulf. |
| VI | 8a | 29.53 | 13a | 29.62 | 5.0 | 3,840 | 768 | " |
| VII | 9p | 29.66 | 13a | 29.62 | 3.5 | 2,784 | 795 | " |
| VIII | 11a | 29.64 | 18a | 29.82 | 7.0 | 3,376 | 482 | " |
| IX | 14p | 29.66 | 20p | 29.76 | 6.0 | 2,960 | 493 | Atlantic. |
| X | 18a | 29.46 | 19a | 29.58 | 1.0 | 880 | 880 | Interior. |
| XI | 19a | 29.56 | 24a | 29.98 | 5.0 | 3,264 | 653 | Gulf. |
| XII | 23p | 29.64 | 25a | 29.74 | 1.5 | 928 | 619 | Interior. |
| XIII | 24a | 29.92 | 31a | 29.44 | 7.0 | 2,128 | 304 | Gulf. |
| XIV | 24p | 29.58 | 27a | 29.64 | 2.5 | 2,144 | 858 | " |
| XV | 25a | 29.78 | 31a | 29.44 | 6.0 | 3,104 | 517 | " |
| XVI | 25a | 29.70 | 27p | 29.54 | 2.5 | 976 | 390 | Interior. |
| | | | | | | Mean | 564 | |

JUNE, 1908.

| | | | | | | | | |
|------|-----|-------|-----|-------|-----|-------|-----|-----------|
| I | 1a | 29.76 | 3a | 29.52 | 2.0 | 992 | 496 | Gulf. |
| II | 2a | 29.48 | 4p | 29.52 | 2.5 | 1,450 | 580 | Interior. |
| III | 4a | 29.54 | 11p | 29.86 | 7.5 | 3,392 | 432 | Gulf. |
| IV | 8p | 29.70 | 17a | 29.86 | 8.5 | 2,720 | 320 | " |
| V | 17a | 29.52 | 22a | 29.70 | 5.0 | 3,200 | 640 | " |
| VI | 22p | 29.56 | 26a | 29.66 | 3.5 | 3,120 | 891 | " |
| VII | 24p | 29.68 | 27p | 29.62 | 3.0 | 1,680 | 560 | Interior. |
| VIII | 27p | 29.62 | 30a | 29.82 | 2.5 | 1,840 | 736 | Gulf. |
| | | | | | | Mean | 584 | |

[illegible]

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FEBRUARY, 1909.

| No. | Beginning. | Ending. | Duration. | Distance. | Apparent average daily velocity. | Disappearance. |
|-----------|-------------|-------------|-----------|-----------|----------------------------------|----------------|
| | in. | in. | days. | miles. | miles. | |
| I | 3a 29° 64' | 6p 28° 98' | 3 5 | 2,528 | 722 | Gulf. |
| II | 4a 29° 48' | 6p 28° 98' | 2 5 | 2,208 | 883 | " |
| III | 5a 29° 36' | 7p 29° 70' | 2 5 | 2,600 | 1,040 | Atlantic. |
| IV | 5p 29° 60' | 7p 29° 70' | 2 0 | 1,800 | 900 | " |
| V | 7a 29° 42' | 10p 29° 30' | 3 5 | 2,760 | 789 | Interior. |
| VI | 11p 29° 63' | 17a 29° 40' | 5 5 | 3,059 | 556 | Gulf. |
| VII | 13a 29° 58' | 17a 29° 40' | 4 0 | 3,136 | 784 | " |
| VIII | 16p 29° 44' | 20p 28° 94' | 4 0 | 3,536 | 884 | " |
| IX | 20a 29° 66' | 25p 29° 02' | 5 5 | 4,200 | 764 | " |
| X | 24a 29° 66' | 27p 29° 58' | 3 5 | 3,168 | 905 | " |
| Mean..... | | | | | 825 | |

MARCH, 1909.

| | | | | | | |
|-----------|------------------|-------------|-----|-------|-------|-----------|
| I | 28p Feb. | 2p 29° 78' | 2 0 | 1,664 | 832 | Atlantic. |
| II | 28p Feb. | 2p 29° 74' | 2 0 | 1,664 | 832 | " |
| III | 1a 29° 38' | 5a 29° 00' | 4 0 | 3,744 | 936 | Gulf. |
| IV | 4p 29° 60' | 7p 29° 62' | 3 0 | 2,880 | 960 | " |
| V | 5a 29° 65' | 7p 29° 62' | 2 5 | 2,016 | 806 | " |
| VI | 5p 29° 78' | 10p 29° 42' | 5 0 | 3,840 | 768 | " |
| VII | 12a 29° 98' | 14p 29° 62' | 2 5 | 2,560 | 1,024 | " |
| VIII | 15a 30° 22' | 18a 29° 48' | 3 0 | 1,920 | 640 | Atlantic. |
| IX | 16a 29° 88' | 20a 29° 58' | 4 0 | 3,040 | 760 | " |
| X | 18a 29° 64' | 21p 29° 72' | 3 5 | 2,240 | 640 | " |
| XI | 19p 29° 72' | 22a 29° 92' | 2 5 | 1,216 | 486 | Interior. |
| XII | 22p 29° 76' | 26a 29° 10' | 3 5 | 2,720 | 777 | " |
| XIII | 22p 29° 68' | 26a 29° 10' | 3 5 | 2,624 | 750 | " |
| XIV | 24p 29° 54' | 29a 29° 08' | 4 5 | 2,432 | 540 | Gulf. |
| XV | 26a 29° 70' | 29a 29° 08' | 3 0 | 2,720 | 907 | " |
| Mean | | | | | 777 | |

The result of the comparison of the preceding table with the microseisms prevailing at corresponding dates may be briefly stated. There is a general relationship between the movements of Lows and microseisms, that is, that during the winter months when the average movement is greater than during the summer months, the microseisms are more frequent and stronger during the former period than during the latter, but when we look for an increase of microseisms with an increase of movement of Lows, we find that the two phenomena are by no means always synchronous. We are therefore obliged to deny the relationship of cause and effect between these two phenomena.

As is shown elsewhere the true relationship lies between the isobars and gradients, their geographic position, the ocean and the microseisms.

MAREOGRAMS.

Very recently through the kindness of Dr. W. Bell Dawson, Superintendent of the Tidal Survey, I had an opportunity of examining the mareograms of St. Paul island for the year 1904, and those for May-December, 1908, the latter, the latest received.

St. Paul is a small rocky island in Cabot strait, the main entrance to the Gulf of St. Lawrence, between Cape North in Cape Breton Island and Cape Ray in Newfoundland, but near to the former. It is almost surrounded by the 100-fathom (183 meters)

line and lies just outside and westward of the St. Lawrence Deep running from the Atlantic ocean (1,000-fathom-line) to the mouth of the St. Lawrence, opposite Matane, a distance of about 630 miles (1,014km.). Cabot strait, 65 miles wide, 250 fathoms deep, is the main entrance to the gulf; the other, the Strait of Belle Isle, is only 11 miles wide at its narrowest part and has less than 50 fathoms of water. The gulf itself is about 450 miles long in a N.W.-S.E. direction, and 350 miles in a N.E.-S.W. direction. The greater part of the gulf is less than 100 fathoms deep.

The object of the scrutiny of these mareograms was to examine the secondary oscillations, which are superposed on the regular tidal movements, and to see if any relationship exists between the occurrence and intensity of these secondary oscillations and the microseisms registered at Ottawa. For the study of the oscillations in the gulf, the mareograms of St. Paul seemed the most suitable.

Secondary oscillations have received considerable attention by various investigators, but so far without conclusive proof of their cause. Last year the Earthquake Investigation Committee of Japan issued a report on 'The secondary oscillations of Ocean Tides.' In the investigation 'Professor Omori was led to the conclusion that the bays or inlets oscillate like fluid pendulums with periods peculiar to their own.'

Records were obtained from many bays about the Japanese coast by specially designed portable tide-gauges and the results tabulated. The period of oscillation was computed by the formula $t = \frac{4l}{\sqrt{gh}}$ where l = length of bay, h = mean depth, and g = acceleration. The denominator represents the velocity of the long waves.

The observed and calculated periods, although ranging for different bays very widely, from 9^m to 363^m, agree pretty well throughout. This part of the investigation seems to show conclusively that each bay has its own inherent period or note like a tuning fork, and will oscillate with its own period 'if it be excited by waves in the external sea having the synchronizing component.' From this it would follow that we can get little or no information about the period of the microseisms as dependent upon the periods of the bays, for microseisms with the same period obtain or prevail over very large areas, tens or hundreds of thousands of square kilometres in extent. However, 'as to the cause of the long waves which manifest themselves as secondary undulations,' the above report says, 'we may mention the wind, the cyclone, the earthquake, &c.' In short, the report does not show that the change of atmospheric pressure is the direct cause of these secondary oscillations and is indicated by them.

Coming now to the mareograms of St. Paul island, it is found that:

- (1) Secondary oscillations are always present throughout the year.
- (2) The range or double amplitude varies, being greater in winter than in summer. The range running from 1cm. to 30cm.
- (3) The period is practically constant throughout the year and years (1904 and 1908), being about 4.6 min., deviating from this by only one or two-tenths of a minute, and this deviation may be partly due to difficulty in measuring the period accurately.
- (4) Small oscillations in amplitude show less interference phenomena than do the larger ones.
- (5) There is a fair correspondence between the occurrence of Lows with steep gradients in or about the gulf and large amplitudes for the secondary oscillations; but this coincidence is not nearly so well marked as in the relation between such Lows and microseisms.
- (6) The cause of these secondary oscillations is in the main due to changes of barometric pressure.
- (7) As the period of the oscillations is practically constant, and the disturbing cause variable, the period must be a function of the topography and hydrography, that is, the depth of water and extent of basin.

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Although the 100-fathom line almost surrounds the island, yet one would not be justified in using its dimensions for computing the period for the oscillations there. Such would give about 31 minutes.

The following table gives the period and range (double amplitude) of mareograms at St. Paul island. The dates are taken more or less at random, but always of such records where the pencil tracings were still clear, as in some cases they were somewhat obliterated by inking in a smooth tidal curve:—

SECONDARY OSCILLATIONS on mareograms recorded at St. Paul island, Cabot strait. The tide-sheets cover alternately 3 and 4 days. Time scale, $1^h = \frac{1}{3}$ inch. Vertical scale, 1 in. = 1 ft.

| Date. | Period. | Range Units of 1/20 ft. | Date. | Period. | Range Units of 1/20 ft. | Date. | Period. | Range Units of 1/20 ft. |
|------------------|---------|-------------------------------|------------------|---------|-------------------------------|-------------------|---------|-------------------------------|
| 1904. | min. | | 1908. | min. | | 1908. | min. | |
| Jan. 3. | 4 0 | 15 | May 18. | 4 5 | 4 | Sept. 11. | 4 6 | 12 |
| " 9. | 4 0 | 20 | " 29. | 4 8 | 11 | " 18. | 4 8 | 5 |
| " 14. | 3 2 | 17 | June 2. | 5 0 | 2 | " 21. | 4 5 | 3 |
| " 27. | 4 0 | 5 | " 7. | 4 6 | 2 | " 25. | 4 8 | 3 |
| Feb. 7. | 4 5 | 4 | " 17. | 4 6 | 7 | " 29. | 4 8 | 2 |
| Mar. 4. | 4 6 | 6 | " 21. | 4 6 | 4 | Oct. 2. | 4 6 | 6 |
| " 23. | 4 3 | 9 | " 23. | 4 5 | 4 | " 6. | 4 8 | 2 |
| " 24. | 4 3 | 3 | " 26. | 4 6 | 3 | " 9. | 4 5 | 3 |
| Apl. 16. | 4 5 | 7 | " 30. | 4 5 | 2 | " 14. | 4 3 | 3 |
| " 18. | 4 4 | 9 | July 3. | 4 6 | 1 | " 20. | 4 5 | 4 |
| May 2. | 4 8 | 3 | " 7. | 4 5 | 2 | " 24. | 4 8 | 3 |
| " 8. | 4 6 | 2 | " 12. | 4 6 | 3 | " 26. | 4 6 | 2 |
| " 18. | 4 6 | 2 | " 14. | 4 5 | 2 | " 31. | 4 6 | 7 |
| June 30. | 4 6 | 2 | " 17. | 4 6 | 2 | Nov. 9. | 4 6 | 3 |
| July 3. | 4 3 | 2 | " 20. | 4 8 | 2 | " 12. | 4 8 | 8 |
| " 7. | 4 3 | 3 | " 24. | 5 0 | 2 | " 16. | 4 5 | 7 |
| Aug. 8. | 4 6 | 2 | " 31. | 4 6 | 2 | " 19. | 4 6 | 8 |
| " 26. | 4 8 | 4 | Aug. 3. | 4 4 | 2 | " 24. | 4 6 | 5 |
| Sept. 1. | 4 3 | 5 | " 7. | 4 6 | 2 | " 27. | 4 4 | 5 |
| " 12. | 4 6 | 3 | " 14. | 4 3 | 2 | Dec. 1. | 4 6 | 5 |
| Oct. 1. | 4 3 | 5 | " 22. | 4 6 | 2 | " 3. | 4 6 | 8 |
| " 8. | 4 3 | 3 | " 26. | 4 3 | 2 | | | |
| Nov. 4. | 4 5 | 4 | " 29. | 4 6 | 8 | | | |
| " 15. | 4 3 | 8 | Sept. 1. | 4 3 | 2 | | | |
| " 25. | 4 5 | 5 | " 4. | 4 5 | 2 | | | |

Another examination of mareograms was made, and that for Trepassey, near Cape Race, Newfoundland, the extreme point jutting into the broad Atlantic. It showed very marked secondary oscillations, exceeding both in period and in amplitude those of St. Paul island greatly. While the mean period of the latter is 4.6 minutes, that of the former is 67.6 minutes, about 15 times as large; and the range reaches over three and a half feet, while for the other it seldom reaches half a foot. The distance apart of these two stations is about 300 miles, but the tidal movement coming from the southeast reaches them about simultaneously. The general movement of the atmosphere or areas of Lows and Highs is easterly, and the barometric conditions prevailing at the two stations are, allowing for time interval in passing from one to the other, fairly similar, yet we find these great differences in the secondary oscillations. We must hence again conclude that their period as well as amplitude must be dependent upon surroundings of the station, *i.e.*, topography-hydrography, or depth of water and extent of basin. Land-locked basins, as shown by the mareograms of Halifax and other places, show little of secondary oscillations, and those shown are generally irregular, which is an experience quite different from that cited for the Japanese coast.

Taking the above two stations which are exposed to the Atlantic, and noting their very different periods, there does not appear to be any very obvious connection between them and the microseisms.

Some investigators believe that the breaking of the waves on the shore sets up tremors in the earth's crust, which may manifest themselves to great distances. To this I am not at present prepared to give assent. My investigations have established more or less synchronous phenomena, but how they are related—as cause and effect—is not yet fully determined.

The following table from the mareograms for Trepassey is similar to the preceding one for St. Paul island. It may be noted that at Trepassey there was at times a tertiary oscillation of a period of 2 minutes or less superimposed on the secondary oscillations. The selection of dates is more or less at random. The mean for each of the four months available is given, and it will be seen that the periods are about the same:—

SECONDARY OSCILLATIONS on mareograms recorded at Trepassey, Newfoundland. Time scale $1^h = \frac{1}{2}$ inch. Vertical scale 1 in. = 6 ft.

| Date. | Period. | Range. | Date. | Period. | Range. |
|--------------|---------|--------|-----------------|---------|--------|
| 1902. | min. | ft. | 1902. | min. | ft. |
| Aug. 22..... | 64 | 3' | Oct. 9..... | 68 | 3.0 |
| " 25..... | 77 | 2.5 | " 13..... | 71 | 3.5 |
| " 26..... | 74 | 3' | " 15..... | 65 | 3.0 |
| " 27..... | 63 | 1.5 | " 23..... | 66 | 3.0 |
| Mean..... | 69.5 | ..... | " 31..... | 64 | 3.0 |
| Sept. 1..... | 65 | 2.5 | Mean..... | 66.8 | ..... |
| " 2..... | 65 | 3.0 | Nov. 3..... | 67 | 1.5 |
| " 5..... | 76 | 2.0 | " 5..... | 64 | 2.0 |
| " 6..... | 68 | 2.5 | " 6..... | 71 | 3.0 |
| " 24..... | 68 | 3.5 | " 11..... | 63 | 3.0 |
| " 26..... | 67 | 2.0 | " 17..... | 64 | 2.0 |
| Mean..... | 68.2 | ..... | Mean..... | 65.8 | ..... |
| | | | Grand mean..... | 67.6 | ..... |

After these various examinations we arrive at the following conclusions:—

- (1) Microseisms are essentially due to meteorological phenomena, that is, to barometric pressure and the accompanying gradients.
- (2) The amplitude of microseisms is largely a function of the steepness of the barometric gradient.
- (3) Areas of low barometer with steep gradients, but west of Ottawa, have little effect in producing microseisms.
- (4) Strong microseisms are almost invariably accompanied by steep gradients in the gulf, with the St. Lawrence valley, containing the Great Champlain fault, on a line of steep gradients.
- (5) A well-marked Low sweeping up the Atlantic coast from Florida to Newfoundland is almost invariably accompanied by marked microseisms.
- (6) Microseisms are but slightly, if at all, influenced by the movement of Lows across the continent.
- (7) Microseisms are not produced by local winds, frictional excitation of the earth's surface.

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- (8) Microseisms represent movements in vast blocks of the earth's crust, covering tens of thousands of square miles; and the period is possibly dependent on or modified by marked geological configuration and depth.
- (9) Microseisms once produced may continue for a day or two when the immediate cause has passed.

ACCELERATION.

The acceleration produced here by earthquakes for the period of the report, April 1, 1908, to March 31, 1909, has in all cases been small. The destructiveness of an earthquake is dependent upon the acceleration and this is measured by the absolute displacement of the earth particles and the period of the oscillation. The absolute displacement is obtained from the seismogram on which the magnified movement is read in terms of millimetres. This latter is converted into absolute measure by application of the magnification factor.

The general expression for the oscillation of a pendulum is $T_o = 2\pi \sqrt{\frac{L}{g}}$ where T_o = period, i.e., the oscillation to and fro, L = length of the pendulum (in metres), g = acceleration for the particular latitude, being for latitude 45° , 9,806 metres, and $\pi = 3.1416$, or the ratio of the semi-circumference of a circle to the radius.

If in a horizontal pendulum we have observed its period, T_o , without damping of the pendulum, the deduced L is called the 'equivalent length,' being that of a simple pendulum having the same period.

As the square root of g (9.81) is approximately the value of π , we obtain the approximate relation

$$T_o = 2 \sqrt{L}, \text{ or } L = \left(\frac{T_o}{2}\right)^2$$

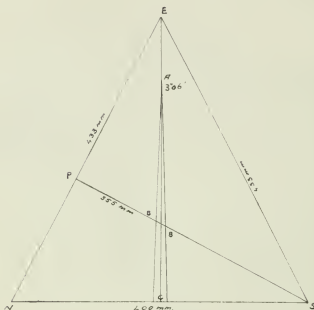
The magnification of the actual movement of the pendulum is effected in seismographs either by a system of levers or by means of a mirror attached to the pendulum. The former method is adopted where there is mechanical registration by a stylus on smoked paper, or by a light glass tube drawn to a fine point and filled with ink, and the latter method for photographic registration as is the case for our seismograph. The magnification in the latter case is simply double the ratio of the actual length of the pendulum to the distance of the recording cylinder from the axis of oscillation of the pendulum.

We may regard the magnification to be produced by the extension of our simple pendulum of the above length L to the length J , which is called the 'equivalent indicator length,' so that the magnification or $V = \frac{J}{L}$. The determination of V for our

Bosch photographic seismograph was made directly from measurements of the parts composing the horizontal pendulum and therefrom computing the length of the simple pendulum that would have the same period as the horizontal pendulum when the latter swung in a vertical plane. This deduced length divided into twice the distance of the recording cylinder gave $V = 120$. Some of the heavy astatic Wiechert pendulums, weight 17,000 kgm. (ours is 200 gms.!) have a lever magnification of upwards of 2,000.

As stated in a previous report, the period of the horizontal pendulum is simply a matter of adjustment of the axis about which it swings with reference to the vertical. We may here give an investigation that I made during the past year for tilting

and period of the east-west pendulum, i.e., of the one giving the north-south component.



In the accompanying diagram E, N, S represent the three footscrews of the pendulum stand. E, N the axis of rotation with reference to tilting done by footscrew S . A is the vertical projection of the lower point of pendulum support.

B is the vertical projection of the upper point of pendulum support, when arc on footscrew S reads 0° .

B' similarly when arc on footscrew S reads 90° .

(Note.—In linear measure the triangle A, B, B' is much exaggerated in scale; the angles are however to scale.)

The top of the base-plate is 92 mm. above the pier.

Lower support above top of base-plate, 27.5 mm.

Centre of bob above top of base-plate, 25 mm.

Distance between supports of pendulum, 166.7 mm.

Thread of footscrew very nearly $\frac{1}{40}$ inch, say $\frac{1}{2}$ mm.

The tilting was done with the south footscrew by turning it through 90° . A special brass arm, graduated through 90° into half-degree spaces and attached concentrically with the footscrew, together with a fixed pointer, opposite the graduations, securely placed on the pier, were used in the experiments.

We have then in linear measure for 90° turn of the footscrew $\frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$ mm., and the angular measure will be θ , where $\sin \theta = \frac{1}{8} \div 355 = .0004401$, hence $\theta = 90'' .8$.

Four measurements of raising and lowering by a quarter turn, or 90° , by south footscrew gave displacements of image at cylinder by pendulum mirror over point of lower support, respectively: $1' 4\frac{1}{2}''$, $1' 5''$, $1' 6''$, $1' 5\frac{1}{2}''$, mean $1' 5\frac{1}{4}'' = 438$ mm.

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Distance of image from mirror, 4,060 mm. Hence angle swept over by image = α , and $\tan \frac{\alpha}{2} = \frac{219}{4060} = .054$, $\alpha = 6' 12''$ and the angle swept over by the pendulum $= \frac{\alpha}{2} = 3' 06''$.

The upper point of support is 166.7 mm. vertically above the lower one. By the quarter turn of the footscrew we have an angular motion of $90''.8$, hence the relative displacement of the upper point of support to the lower one will be x , where $\frac{x}{166.7} = \tan 90''.8$, therefore $x = .073382 \text{ mm.} = B B'$.

This displacement is in a plane, perpendicular to the axis of rotation EN . Reducing to the perpendicular of AC this becomes .06509 mm.

Remembering that AC is the normal position of the pendulum, we have in the triangle formed by the two positions of the upper point of support and the lower one due to readings of 0° and 90° on the footscrew, the angle at the apex $3^\circ 06'$ from above, and the reduced opposite side .06509 mm., hence the horizontal distance between the two points is d , where $.06509 \div d = \sin 3^\circ 06'$, therefore $d = 1.2036 \text{ mm.}$

It follows that the angle between the points of support and the vertical is γ , where $\tan \gamma = \frac{1.2036}{166.7} = 24' 49''.25$.

By previous determination we have the distance from the centre of oscillation to the axis of rotation of the pendulum 66.774 mm., hence the length of the equivalent pendulum is $L = \frac{66.774}{\sin 24' 49''.25} = 9248.4 \text{ mm.}$, therefore the period = $2\pi \sqrt{\frac{L}{g}} = 6''.10$ (g for $45^\circ = 9806 \text{ mm.}$)

By direct observation on the day of the above investigation, the period was found to be $6''.15$, being in satisfactory agreement with the above value.

The method of deflection of image is more accurate for the determination of the period than direct observation.

For the above adjustment of pendulum $1''$ tilting was equivalent to a displacement of the image of 5.42 mm., or 1 mm. deflection of image = $'' .184$ tilting north-south. Similar experiments were carried out with the other pendulum, the $N-S$ one, giving the east-west component. The instrument is identical with the other; it is mounted on the same pier, but its adjustment was different at the time.

For it was found a period of $12''.56$, and 1 mm. deflection of the image represented a tilt of $'' .0444$. As one can read to a tenth of a millimetre, we see that for the adjustment of the latter pendulum one can detect tilting of $'' .0044$, which is equivalent to about 1 inch in 710 miles.

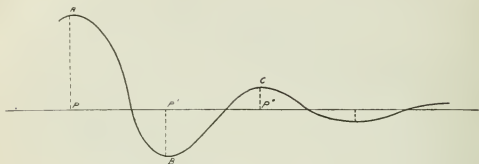
Without damping, a horizontal pendulum set in motion would continue to oscillate for an indefinite time and with equal amplitudes, leaving out of consideration for the moment the effect of friction at the points of support. This latter would effect a reduction in amplitude in arithmetical progression.

As the principal function of the seismograph is to record the true movements of the earth, both in time and magnitude, it is essential that its own personality regarding swing should be obliterated as much as possible, that is, that it should subside unless acted on by the earth movements. This is effected to a greater or less degree by air, oil or electro-magnetic damping. In our Bosch instrument an air chamber forms a cushion within which a vane of the pendulum moves.

The effect of damping is to reduce the amplitudes in geometrical progression instead of arithmetical, as in the case with friction. Friction will ultimately stop a pendulum, but with damping the amplitude curve is asymptotic, and hence the time infinite.

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The 'damping ratio' is understood to be the ratio of the amplitude of a swing from the zero line to the next amplitude on the opposite side, as shown by the accompanying diagram.



Damping ratio = $\frac{A}{B} \frac{P}{P'} = \frac{B}{C} \frac{P'}{P''} = 1 : f$; hence in time $\frac{T}{2}$, where T = period of damped pendulum we have the ratio $1 : f$.

In time $2 \left(\frac{T}{2} \right)$ the ratio $1 : f^2$, and in general for $n \left(\frac{T}{2} \right)$ the ratio is $1 : f^n$.

If we call $x \left(\frac{T}{2} \right)$ the time in which the amplitude is reduced $\left(\frac{1}{e} \right)^{\text{th}}$ of its value, where e is the base of the natural or Napierian logarithms, then for time $x \left(\frac{T}{2} \right)$ we have $1 : f = 1 : e^{-1}$.

Let $\tau = x \left(\frac{T}{2} \right)$, $\therefore x = \frac{2\tau}{T}$, hence $1 : f = 1 : e^{-\frac{1}{f}} = 1 : e^{-\frac{2\tau}{T}} = e^{\frac{2\tau}{T}} : 1$.

The quantity $e^{\frac{2\tau}{T}}$ is generally designated by ϵ .

The effect of damping changes the period of the pendulum when swinging freely, and the relation between the two is expressed by

$$T_0 = \frac{T}{\sqrt{1 + \left(\frac{T}{2\pi\tau} \right)^2}}$$

in which T is the damped period.

The magnification of the earth movement of earthquakes, as recorded on the seismogram by the damped pendulum, is dependent upon the period of such earth movement, hence the magnification is not a constant quantity for interpreting the amplitudes. Professor Wiechert in his 'Theorie der automatischen Seismographen,' gives the following formula for the derivation of the magnification:—

$$\mathcal{V} = \frac{V}{\sqrt{\left\{ 1 - \left(\frac{T_v}{T_0} \right)^2 \right\}^2 + 4 \left(\frac{T_0}{2\pi\tau} \right)^2 \left(\frac{T_v}{T_0} \right)^2}}$$

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From relations we have found before, this may be put in the form

$$\epsilon^2 = \frac{V}{\sqrt{\left\{1 - \left(\frac{T_e}{T_o}\right)^2\right\}^2 + 4 \frac{(\text{nat. log } \epsilon)^2}{\pi^2} \left(\frac{T_e}{T_o}\right)^2}}$$

or using the common logarithms we have

$$\epsilon^2 = \frac{V}{\sqrt{\left\{1 - \left(\frac{T_e}{T_o}\right)^2\right\}^2 + \frac{4 (2.303 \log \epsilon)^2}{1 + (2.303 \log \epsilon)^2} \left(\frac{T_e}{T_o}\right)^2}}$$

in which T_e is the period of the earth particles; T_o is the period of undamped pendulum; and the other symbols as previously designated.

It will be observed that this gives wide variations in the magnification, dependent upon the relative values of T_e and T_o , and also upon the damping co-efficient. The value best suited for ϵ lies between 3 and 8.

We now come to the evaluation of the acceleration from the amplitude and period of the recorded earth movements. We have the general expression for normal acceleration $= \frac{v^2}{r}$, in which $v = \frac{2 \pi r}{T_e}$, and r is the amplitude, or half range of the oscillation

measured on the seismogram, and expressed in microns or $\frac{1}{1000}$ millimetres. The value of r is obtained by dividing the linear measure on the seismogram by the appropriate π for the particular period of T_e . The result is expressed in milligals, where 1 gal is the acceleration of 1 cm. = 10 mm. = 10,000 μ per second, per second, and a milligal is $\frac{1}{1000}$ of a gal. Gravity would therefore be represented by 980.6 gal (for $\phi = 45^\circ$), so that approximately a milligal is the one millionth of gravity.

The acceleration Δg in milligals is given by the approximate formula $\Delta g = \frac{4 A}{T_e^2}$, where A is the amplitude ($\frac{1}{2}$ range) expressed in microns, and T_e the period in seconds.

As Ottawa is several thousand miles from the nearest seismic area—the West Indies, Mexico or California—the acceleration produced here is always very small, and of course the destructive earthquakes which have occurred there in recent years were not felt here.

During the year, April 1, 1908, to March 31, 1909, the greatest acceleration was produced by the earthquake of November 30, where the period was 10^s, and the amplitude 125 μ . This gives an acceleration of 4.9 milligals or about the $\frac{1}{200,000}$ that of gravity.

For the disastrous Messina earthquake of last December the following accelerations have been computed. Most of the weekly or monthly earthquake reports received from other stations do not give sufficient data to compute the acceleration:—

| | Distance. | T_e | A | Δg |
|-------------------|-----------|-------|-------|------------|
| | km. | s | μ | |
| Ottawa | 7,200 | 16 | 18 | 3 |
| Granada | 1,700 | 12 | 750 | 21 |
| Graz | 1,000 | 20 | 1,100 | 11 |
| Jena | 1,400 | 19 | 3,000 | 33 |

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In closing this part of my report, on seismology, I desire to express the hope that at no distant day, quarters will be erected for the machine shop; for the operation of the machinery in the basement of the Observatory, as at present, is a menace to the satisfactory functioning of the seismograph.

TERRESTRIAL MAGNETISM.

In continuation of the systematic magnetic survey of Canada begun last year, stations were occupied during the past summer, mostly in British Columbia, and the observations were made by Mr. C. A. French. The stations occupied were: Ottawa, Agincourt, Winnipeg, Banff, Golden, Revelstoke, Sicamons, Clinton, Barkerville, Quesnel, Alexandria, Williams Lake, Bridge Creek, Ashcroft, Spence's Bridge, Nicola, North Bend, Agassiz, Vancouver, Victoria and Nanaimo. The magnetic observations were all made in a tent, carried along for the purpose. Instruments used were: Tesdorpf magnetometer 1977, Dover Dip circle 145, Dent Mean Time chronometer 511, and a six-inch Troughton-Sinms theodolite for azimuth, latitude and time observations.

In order that the observations of the elements of terrestrial magnetism in different parts of the earth may be strictly inter-comparable, it is essential that the constants of the instruments employed be referred to standard instruments, preferably at basal stations. By such comparisons, repeated from time to time, say at the beginning and end of the season of field work, one is enabled to give a homogeneity and confidence to the results which would otherwise be lacking, and would militate against their value for incorporation in the general discussion of the difficult problems presented by terrestrial magnetism.

There are several departments of physical investigation in which little progress has been made during the last fifty years in getting at the fundamentals underlying the elements involved. One of them is terrestrial magnetism. In 1904 the Carnegie Institution of Washington undertook to attack the problem in a comprehensive manner, especially in supplying magnetic data for the accessible regions of the world not before occupied, and more particularly to make a systematic magnetic survey of the various oceans, for which purpose a specially built non-magnetic vessel, the *Carnegie*, has been built and which was recently launched at Brooklyn. This work, combined with the Solar Research at Mt. Wilson, also under the auspices of the Carnegie Institution, should in the near future unravel some of the mysteries that have hitherto enshrouded that subtle force or energy—Terrestrial Magnetism.

Toronto is and has been one of the principal magnetic stations in the world, although the location of the instruments now, is not where the original ones were mounted. This change in 1898 to Agincourt, some 10 miles distant, was necessitated through the introduction of the electric cars in Toronto. Since beginning our systematic magnetic survey of Canada complete sets of magnetic observations—declination, inclination and horizontal intensity—have always been made with our field instruments at Agincourt and compared with the results of the standard instruments there, thereby standardizing the former. A similar comparison was made with our Tesdorpf magnetometer 1977 through the kindness of Dr. L. A. Bauer, Director of the Department of Terrestrial Magnetism, Carnegie Institution, at Washington, in April, 1908, with results practically identical with those at Agincourt.

For further comparisons, and more particularly for the comparison of different magnetic instruments, there has been erected during the past year on the Observatory grounds here, a magnetic hut, an illustration No. 1, thereof, accompanying this report. Its dimensions are 10 x 15 feet. It is scarcely necessary to say that no iron or steel of any description was used in the construction. The nails are all copper; hinges, &c., of brass, all tested for non-magnetism before use. The two pillars for mounting the instruments are solid cedar posts surmounted by brass plates 11½ inches

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in diameter, which are grooved with three diameters, dividing the surface into sectors of 60° , for the footscrews of the instruments. When observations are made at night, petroleum is used for illumination. There is a permanent azimuth mark about a quarter of a mile distant. The Observatory grounds are just outside of the city limits and the vicinity is fairly free from traffic. The nearest approach of an electric ear line to the magnetic hut is 1,492 feet (455 m.). The cars run from 6 a.m. to 12 p.m. on this line. In order to test whether the current of the line exercised a magnetic influence at the hut, observations were made for three days during the 24 hours for declination. There was no effect noticeable during the day-time when the cars were running, and for different positions of the cars on the line with reference to the hut and power station; nor for the time after midnight. The change in declination for each 24 hours followed the general daily curve of eastern and western elongation. Further on will be found the record of these observations. In the future, observations will be made here with the field instruments at the beginning and close of the season's work.

The following 'Memorandum for Magnetic Observations, 1908,' was issued to the observer:—

'In the selection of new stations regard should be had for future occupation for the same points.

The vicinity of trolley lines should be avoided; the magnetic station should be at least a mile from the line.

The station selected is to be connected by linear measure with established corners of lots or intersections of streets, so that it may be accurately re-established at any future time. The azimuth of two or more well recognized objects from the station is to be obtained, either by observation on the sun at about 9 a.m. or 3 p.m., or on Polaris, the former by observing the altitude, circle right and circle left, and the latter by noting the sidereal time when sighting on Polaris, circle right and circle left.

The nature of the ground, whether there are any rock exposures, and surrounding topographic features are to be noted.

A sketch is to be made for each station, showing its relative position, and that of the astronomic meridian.

The order of the observations in general are:—

1. Azimuth.
2. Declination.
3. Dip.
4. Oscillation.
5. Deflection.
6. Deflection.
7. Oscillation.
8. Dip.
9. Declination.

Suspension of weight and removal of torsion for fibre declinometer require particular attention.

The mean of the times for dip, oscillations and deflections will be approximately the same when observing in the above order.

The observations are to be entered on the forms supplied.

Before leaving a station all the observations are to be reduced, with a sufficient degree of accuracy to ensure their reliability.

On your way west you will go via Toronto, and at Agincourt (the Magnetic Observatory) take a full set of observations with both the Tesdorpf and Dover, for the latter especially to obtain the value of λ , not forgetting to note temperatures throughout all the observations. Particular attention will be paid to the determination of the declination and the constant of correction for the declination magnet, 10.

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After all the observations have been satisfactorily made, you will proceed to Winnipeg and re-occupy the Carnegie Institution station in the park, the description of the station is hereto attached, also the former magnetic values. The azimuths given will be re-determined, and a full set of satisfactory magnetic observations taken.

Similarly Banff will be occupied, the necessary data are also attached.

The names of the other stations to be occupied are appended:—Golden, Revelstoke, Sicamous, Ashcroft, Clinton, Bridge Creek, Williams Lake, Alexandria, Quesnel, Barkerville, Spence's Bridge, Nicola, North Bend, Agassiz, Vancouver, Victoria, Nanaimo (Departure Bay).'

Description of Stations occupied.

Ottawa.—The station (not the magnetic hut) was situated in the southeastern part of the observatory grounds; it was 81 feet from the easterly limit and 53 feet from the southerly limit of the grounds. This station was occupied by the Carnegie Institution in October, 1906, and in 1907-1908 by our observers. It is now abandoned owing to the erection of the Director's house nearby. The reference object was the flag-staff on the central tower of the Parliament Buildings. True bearing, N. 16° 59' 0 W.

Agincourt.—The magnetic observatory.

Winnipeg.—Same station as occupied by the Carnegie Institution in 1906. It is in River Park, about half a mile east of park entrance, in the first cleared space beyond the grove of small trees that surround the entrance. It is about 15 paces from the top of the north bank of the Red river and in line of the fence bounding the buffalo pasture on the side adjacent to the river. It is about 330 feet southwest of the south corner of the pasture. Two grain elevators in the distance, and a small red barn in the pasture are seen nearly in line from the station. A red water tank is seen near the elevators and a little to the west of the barn. The following true bearings were determined:—

| | |
|---|--------------------|
| Smokestack near International Elevator C. | 39° 18'.8 E. of N. |
| Pole on the red water tank. | 23° 40'.0 E. of N. |
| West gable of a large white house. | 47° 28'.6 E. of N. |

Banff.—The station is the same as that occupied by the Carnegie Institution in 1907. It is in the grounds of the National Park Museum, 292 feet south-southwest of the southwest corner of the museum building, midway between, and in line with, the two small spruce trees near the north bank of Bow river and nearest to a pen used at present for ducks. The point was marked by a round pine stake (about two inches in diameter and about eight inches long) driven flush with the surface. The stake is 67½ feet from the northeast corner of the duck pen and 93½ feet from the southeast corner, and is about 10 feet north of bank of river, and furthermore about in line with the west side of a one-story building in the rear of the Canadian Pacific Railway Museum on the north bank of the Bow river. The bearings of the following objects were obtained:—

| | |
|--|--------------------|
| Meteorological Observatory, Sulphur Mt. anemometer pole, 8° 07'.2 W. of S. | |
| Sanitarium hotel, bottom of flagstaff, east tower. | 27° 19'.2 E. of S. |

Golden.—The station (1908) is on the property of Mr. Alexander, in a clearing on the south bank of the Kicking Horse river. It is about 200 feet east of the road-bed of the proposed Kootenay railway, and is midway between the ends of that portion of the bank along which is a breakwater consisting of a layer of small trees. From the station the top of the Columbia hotel is visible above the wooden bridge over the Kicking Horse river, and the front of the Queens hotel is seen to the east of the fire-hall.

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The point is marked by a round wooden peg 2 inches in diameter, and projects about an inch above the ground. It is distant 190 feet 3 inches from the northeast corner of a vacant log house; 261 feet 9 inches northeast from the southeast corner of a lot, one side of which is on Calgary street and the other parallel to the Kootenay Railway road-bed, and 234 feet southeast from the northeast corner of a lot adjacent to the first mentioned one. True bearings of the following reference objects were obtained:—

| | |
|--|-----------------|
| Bottom of pole on C. P. R. water tank. | N. 36° 51'.1 W. |
| Bottom of flagpole on Columbia hotel. | N. 49° 35'.8 W. |
| Bottom of flagpole on Parson's store. | N. 80° 03'.9 W. |

The magnetic observations were taken 13 feet 3 inches southeast from station and in line with pole on tank. The soil is gravel.

Revelstoke.—The station is located on the Athletic grounds in the southwest part of the town. It is about 45 paces east of the bank of the Columbia river. The top of the Catholic church may be seen a little to the left of the line joining the station with the Canadian Pacific Railway water tank. The station is marked by a peg 2" x 1½" driven flush with the ground, and is 71 feet 8 inches from the northeast corner of the grand stand and 68 feet from the southeast corner. The true bearings of the following reference objects were obtained:—

| | |
|---|-----------------|
| Bottom of pole on west water tank on mountain side. N. 33° 28'.1 E. | |
| Top of belfry on school. | N. 6° 03'.8 W. |
| Bottom of pole on Court House. | N. 12° 53'.7 W. |

The magnetic observations were taken at a point 8 feet 3 inches southwest from station and in line with water tank.

Sicamous.—The station is located in a clearing on the south side of the Canadian Pacific Railway, and on the east side of the narrow part of Shuswap lake. The Canadian Pacific Railway hotel may be seen between the pump-house and the first telegraph pole to the west of the semaphore. It is almost directly in line with the north end of the Bellevue hotel. The spot is marked by a round post about 2 inches in diameter, driven so as to project 3 inches above ground. It is 18 feet 9 inches from a large poplar tree and southeast of it, and is 14 feet from another round post about 1½ inches in diameter, which is in line with the station and tree. It is 172 feet from the east end of the Canadian Pacific Railway bridge.

The true bearings of the following points were obtained:—

| | |
|--|-----------------|
| Top of pyramid over east bay window, C.P.R. hotel. S. 67° 56'.7 W. | |
| North end of peak of Bellevue hotel. | S. 39° 39'.0 W. |

The magnetic observations were taken 9 feet southeast from station and in line with Canadian Pacific Railway hotel.

Clinton.—The station is in the southeast part of the town in a field owned by Mr. Smith. It is on a slight elevation about 30 paces to the south of the road leading to the cemetery. It is marked by a brass nail in a fir stake 2" x 4", driven 18 inches into the ground and projects 7 inches. It is 143½ feet northwest of the post which marks the northwest corner of the cemetery, and 144 feet southwest from the south large gate-post.

The true bearings of the following reference objects were obtained:—

| | |
|--|-----------------|
| Top of church tower, Indian reservation. | S. 70° 07'.3 W. |
| Pole on cottage, rear of Provincial Land Office. | N. 88° 18'.7 W. |
| Pole on cottage (Dr. Sanson's). | N. 69° 30'.5 W. |

The magnetic observations were taken 25 feet northeast from station and in line with spire on Catholic church.

Barkerville.—The station is in a small clearing on the west side of the road which leads from the south of the town. It is about 336 feet (by way of road) from the

bridge which crosses the ditch constructed for conveying water used for mining purposes, which is about 45 paces from the south end of the bridge which crosses the river (now dug). The station is marked by a brass tack in the top of a fir post 3" x 4" which projects 3 inches above the ground. It is 39 feet from the middle of the road and 37 feet from a spruce tree which is to the south of it, and in line with a point slightly to the east of the Presbyterian church.

The following true bearings were determined:—

| | |
|---|-----------------|
| Pole on Fire Hall. | S. 72° 08'.7 W. |
| Pole on Masonic Hall. | N. 80° 32'.3 W. |
| West gable on belfry Presbyterian church. | N. 44° 59'.5 W. |

The magnetic observations were taken 12 feet east from the station and in line with the pole on the Fire Hall.

Quesnel.—The station is on government property, north of the town. It is about 318 paces from the ferry cable, and is marked by a brass tack in a fir post 2" x 4", driven so as to project 8 inches above ground. It is 15 feet from the bank of the Fraser river, and 76 feet 8 inches northwest from the corner post of the fence around a small field which is adjacent to the post office property. There are three clumps of spruce trees about 75 feet south, and are so situated that the Catholic church and post office may be seen between the easterly pair; the pole of Reid's store between the westerly pair; and the grist mill to the right of the westernmost one.

The following true bearings of reference objects were obtained:—

| | |
|--|-----------------|
| Bottom of cross on church. | S. 28° 10'.7 E. |
| Gable of wing of post office. | S. 22° 54'.4 E. |
| Pole on Reid's store. | S. 14° 47'.4 E. |
| Gable of ventilator on grist mill. | S. 2° 06'.9 E. |

The magnetic observations were taken 8 feet northwest from station and in line with pole on Reid's store.

Alexandria.—The station is on a waste piece of land in the northwest corner of a field belonging to Mr. Anders. The field is on the west side of the government road opposite the post office and farm buildings, and borders on the Fraser river. It is marked by a brass tack in a fir post 5 inches in diameter, which projects 8 inches above ground. It is about 95 feet northeast from the end of the trail which leads to the post office landing; 56 feet from the bank, and 57 feet southeast from a forked tree. The soil is a layer of sandy loam over gravel.

The following true bearings of reference objects were obtained:—

| | |
|---|-----------------|
| West chimney on Mr. Anders' house. | S. 73° 20'.7 E. |
| Spire, Catholic church, Indian reservation. | S. 3° 30'.0 W. |

The magnetic observations were taken 12 feet northwest from station and in line with west chimney on Mr. Anders' house.

Williams Lake.—The station is southwest of the town on property belonging to the Cariboo Trading Company. The point is marked by a brass nail in a fir post 4" x 4", which projects 7 inches above ground. It is about 132 paces west of the Government Road, and a line joining it with the centre of the school passes over the entire length of a fairly large irrigation ditch. A telegraph pole obscures the lower part of the pole on the top of the school. The station is 87 feet from the point where the ditch branches into two, one taking a northwest direction and the other a southwest one. The ground is covered with stones and boulders. The soil is of a soft, black nature.

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The following true bearings of reference objects were obtained:—

| | |
|---|-----------------|
| Top of north chimney on large frame house. | S. 22° 12'.0 E. |
| Top of small pole on school. | N. 88° 20'.5 E. |
| Bottom of pole on ventilator C. T. Co.'s barn. | N. 7° 52'.5 E. |
| Bottom of pole over bay-window, white house W. of hotel. | N. 6° 38'.1 W. |

The magnetic observations were taken 25 feet northwest from station and in line with chimney on large frame house.

Bridge Creek.—The station is located on property belonging to Stephenson Bros., and is on the south edge of a fir grove which is in a field to the northwest of the ranch buildings, being 145 feet from the point where the irrigation ditch passes under the fence adjacent to the Cariboo road, and about at right angles to it. It is marked by a brass nail in a fir post $4\frac{1}{2}$ " x 4", which projects 7 inches above ground.

The true bearings of the following reference objects were obtained:—

| | |
|--|-----------------|
| N.W. corner of chimney on N. of dwelling house. | S. 28° 30'.1 E. |
| Gable of house situated to S.W. of dwelling house. | S. 14° 38'.9 E. |
| Chimney on machine shop in open field. | S. 14° 16'.4 W. |

The magnetic observations were taken 12 feet northwest from station and in line with the central reference object.

Ashcroft.—The station is the same as that occupied by the Carnegie Institution in 1907. The station is in a field in the southern part of the town, owned by the British Columbia Express Company. It is 100 feet east of the bank of the Thompson river, about 1,000 feet from the Canadian Pacific Railway track, and about 500 feet from the nearest building. The station is marked by a brass screw in the top of a fir post $3\frac{1}{2}$ " x $3\frac{1}{2}$ " x 30", set so as to project 11 inches above the ground.

The following true bearings were determined:—

| | |
|--|--------------------|
| Presbyterian church spire. | 0° 17'.8 W. of N. |
| English church spire. | 14° 36'.4 E. of N. |
| Corner of red house on hill. | 45° 41'.5 E. of N. |
| Telegraph pole marked 48. | 3° 19'.6 E. of S. |
| Vertical edge of rock pinnacle on opposite bank of river. | 12° 50'.2 W. of S. |

The magnetic observations were taken 14 feet west from the station and in line with the Presbyterian church spire.

Spence's Bridge.—The station is a little less than half a mile west of the railway station, in a field belonging to Mr. Clemes. It is marked by a brass nail in a fir post 4" x 4" projecting 12 inches above ground, and is 61 feet 5 inches from the north corner post of the cemetery and almost in line with the diagonally opposite post, and is 110 feet 7 inches from the east corner post and 115 feet from the west corner post. (The diagonals of the cemetery are almost N.-S. and E.-W.)

The following true bearings of reference objects were obtained:—

| | |
|---|-----------------|
| Corner of post of water tank on mountain side. | N. 42° 21'.8 W. |
| Centre of circle on white cross (being headstone on grave in cemetery on opposite side of river. | N. 11° 27'.4 W. |
| Pole on C. P. R. water tank. | N. 64° 31'.6 E. |
| Bottom of post marked 'Yard Limit' on C.P.R. | S. 27° 47'.6 W. |

The magnetic observations were taken at a point 25 feet west from station, and in line with pole on Canadian Pacific Railway water tank. Soil, loose sand and gravel.

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Nicola.—The station is opposite the Canadian Pacific Railway station in a field owned by Mr. House. It is marked by a brass nail in a fir post 2" x 4", projecting 7 inches above ground. The point is about 165 paces southwest of the end of the 'Y.' 62 feet east of a small irrigation ditch and 22 feet north of a line joining the bottom of the north row of stakes in the fence along the south boundary of the field.

The following true bearings of reference objects were obtained:—

| | |
|---|-----------------|
| Gable end C. P. R. station. | N. 33° 35'.7 E. |
| Gable end C. P. R. engine shed. | N. 49° 51'.4 E. |
| Vertical edge of large boulder on mountain side. . | N. 86° 03'.0 E. |
| Chimney on south wing of house (this wing painted red). | S. 2° 55'.8 W. |
| Gable of large red barn, about a mile distant. . | S. 34° 30'.5 W. |

The magnetic observations were taken 12 feet northeast from station, and in line with chimney on house. Soil, fine gravel.

North Bend.—The station is southwest of the town on the property of Mr. Phinister. It is on a waste piece of land beyond the first enclosure at the rear of the post office, and is about 650 feet from the Canadian Pacific Railway tracks. It is marked by a brass nail in a fir post 4" x 4", projecting 12 inches above ground. The point where the line through the station and the pole on the Canadian Pacific Railway water tank, intersects the continued line of the straight rail fence running north-westerly from the northwest corner of the post office is 38 feet from the station, and 86 feet from the end of the fence.

The following true bearings of reference objects were obtained:—

| | |
|---|-----------------|
| Pole on C. P. R. water tank. | N. 25° 46'.2 E. |
| Small pole on south end of Mountain View hotel. . | N. 46° 39'.9 E. |
| Small pole on west end of C. P. R. hotel. | N. 58° 36'.9 E. |
| Bottom of cross on Catholic church. | N. 88° 57'.1 E. |

The magnetic observations were taken 8 feet southwest from the station and in line with the pole on the water tank.

Agassiz.—The station is on the grounds of the Agassiz Agricultural Association. It is marked by a fir stake 2" x 4" driven flush with the ground. It is about 9 feet inside the race-track and is 165 feet 10 inches from the point in the east fence which is 167 feet from the northeast corner of the grounds, and 173 feet 10 inches from the point in the west fence which is 165 feet from the northwest corner of the grounds; the above distances to the east and west fences are in the same straight line.

The following true bearings of the reference objects were obtained:—

| | |
|---|-----------------|
| Gable of porch in front of Presbyterian church. . | S. 27° 42'.0 W. |
| Gable of building in southwest corner of grounds. . | S. 60° 49'.1 W. |
| Top of ventilator on hop barn. | N. 56° 17'.8 W. |

The magnetic observations were taken 31 feet northeast from the station and in line with the Presbyterian church. Soil, sandy loam.

Vancouver—Brockton Point.—The station is on the Government Lighthouse Reserve, on which is also the small Dominion Astronomical Observatory, used as a reference station for longitudes in British Columbia. It is 43 feet southerly from the southwest corner of the observatory building (office part), and eight feet due west from the produced line of the west end of building.

The following true bearing of the distant reference object was obtained:—

Steeple Catholic Indian mission church, North Vancouver, N. 50° 22'.6 E.

The magnetic observations were taken at the above point.

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Victoria.—The Coast and Geodetic Survey station of 1903, as described in the C. & G. S. report of 1903, p. 1003, is as follows:—‘On the southeastern edge of the city, about 500 feet in a southwesterly direction from the flagpole in Dr. Millin’s yard (Dallas road and Dallas ave.) and 12 feet from the edge of the bluff overlooking the beach, between Holland point and Finlayson point. The station is marked by a 2" x 4" fir stub set flush with the ground. The flagpole in Dr. Millin’s yard bears $65^{\circ} 03'.3$ east of true north; Race Rocks lighthouse bears $43^{\circ} 18'.8$ west of true south.’

The following was received from the Carnegie Institution:—‘L. A. Bauer, of the Carnegie Institution, re-occupied this station in August, 1907, having found a fir stub projecting about 2 inches in the locality described above. However, two sets of azimuth observations gave for the azimuth of the first mark $64^{\circ} 53'.1$ E. of N., and the second mark $43^{\circ} 12'.3$ W. of S. Apparently there are two stubs in close proximity which it will be well to investigate if the station is re-occupied.’

A stub or peg was found projecting slightly above ground, evidently the one found by Dr. Bauer, of the Carnegie Institution. This peg, being badly decayed and broken, was replaced by one 4" x 4", set flush with the ground.

The following true bearings of reference objects were obtained:—

| | |
|--|--------------------------|
| Flagpole in Dr. Millin’s yard. | N. $64^{\circ} 51'.0$ E. |
| Race Rocks lighthouse. | S. $43^{\circ} 13'.7$ W. |
| Buoy on Brothey ledge. | S. $72^{\circ} 20'.9$ W. |

The magnetic observations were taken 12 feet northeast from the station and in line with the lighthouse.

Nanaimo.—The station is on the side of Jesse island, which faces south and west. It is marked by a fir post which projects 18 inches above ground, and has a mound of earth and stones around it one foot in height. It is about 45 paces from the edge of the bank, and 160 paces from the cliff near the northwestern part of the island.

The following true bearings of reference objects were obtained:—

| | |
|---|--------------------------|
| Pole on water tank at Brekin mine. | S. $8^{\circ} 16'.7$ W. |
| Chimney on west end of large white house at northwest part of bay. | S. $86^{\circ} 01'.0$ W. |

The magnetic observations were taken 12 feet north from the station and in line with the pole on the water tank.

To occupy the stations between Ashcroft and Barkerville required a stage-drive of fully 500 miles.

On September 4, 1908, a magnetic storm manifested itself at Williams lake, as shown by the following readings for declination, magnet erect. The observations began at 16^h 30^m Pacific Standard Time; this would be equivalent to 0^h 30^m (a.m.) Greenwich Mean Time of September 5.

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| Vernier A. | Time. | Vernier A. | Time. | Remarks. |
|------------|-------|------------|-------|--|
| | h. m. | | h. m. | |
| 177° 04' 8 | 16 30 | 177° 22' 5 | 17 10 | Reference object A = 307° 36' 1. B = 127° 36' 0. Azimuth R. O., S 22° 11' 2 E. |
| 6.3 | 32 | 26.3 | 12 | |
| 4.5 | 37 | 26.7 | 14 | |
| 6.2 | 40 | 22.7 | 16 | |
| 6.7 | 41 | 14.7 | 24 | |
| 10.1 | 42 | 2.0 | 30 | |
| 10 2. | 44 | 176° 56' 6 | 32 | |
| 4.2 | 46 | 44.1 | 33 | |
| 0.5 | 48 | 38.0 | 34 | |
| 4.5 | 50 | 177° 10' 6 | 38 | |
| 8.9 | 52 | 176° 36' 1 | 43 | |
| 16.2 | 54 | 177° 00' 0 | 46 | |
| 16.2 | 56 | 176° 52' 8 | 50 | |
| 12.6 | 58 | 177° 10' 9 | 52 | |
| 6 2. | 17 00 | 8.0 | 18 00 | |
| 8.9 | 2 | 18.0 | 10 | |
| 12.0 | 4 | | | |
| 8 3. | 6 | | | |
| 14.0 | 8 | | | |

The needle was very unsteady also on the following day (5th). On September 11 and 12, while at Ashcroft, the needle showed unsteadiness. There was a fine auroral display on the evening and night of September 11.

The following readings of the declination magnet show the disturbances at Ashcroft on September 11, 1908.

Time—Pacific Standard—eight hours slow on Greenwich.

| Vernier A. | Time. | Remarks. |
|------------|-------|---|
| | h. m. | |
| 243° 24' 8 | 14 01 | Reference object A = 215° 14' 3. B = 35° 14' 2. Az. of R. O. = N, 0° 17' 8 W. |
| 28.5 | 3 | |
| 22.0 | 12 | |
| 28 0 | 16 | |
| 18.0 | 22 | |
| 14 3 | 28 | |
| 242° 54.6 | 43 | |
| 58.5 | 46 | |
| 243° 12.3 | 49 | |
| 22.3 | 54 | |
| 16 1 | 15 03 | |
| 19 4 | 07 | |

The range of declination at Williams lake on September 4, during the 1^h 40^m of observation, was 50' 6; and at Ashcroft on September 11, during 1^h 04^m, was 33' 9. On the afternoon of September 12, at Ashcroft, the magnet was quite steady. The observations at neither place were sufficiently continuous to obtain the extreme range, east and west, that the magnet attained.

The magnetic storms of those days were undoubtedly world-wide. Dr. C. Chree, of Kew, makes note of them in 'Nature,' of September 24, 1908. Referring to the declination, he says: 'The extreme easterly position was reached at about 2.53 a.m.,

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and the extreme westerly position at about 5.14 a.m. on September 12, the total range of declination being about $1^{\circ} 27'$. The movements on September 12 were the most rapid. Between 1.24 a.m. and 1.46 a.m. there was a westerly movement of about $51'$, followed in the course of the next eight minutes by an easterly movement of about $35'$, while between 2.58 a.m. and 3.28 a.m. there was a westerly movement of about $53'$. There were no large movements after 6 a.m.

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TABLE I.

Stations occupied during 1908. The declinations are all reduced to 10.30 a.m. local time for the position of the average meridian for the day and place.

| Place. | Latitude. | Longitude. | Year. | Month & Day. | Hour & Minute. | Declination. | Month & Day. | Hour & Minute. | Dip. | Month & Day. | Hor. intensity C.G.S. Units. |
|------------------|-----------|------------|-------|--------------|----------------|--------------|--------------|----------------|---------|--------------|------------------------------|
| Winnipeg, Man. | 49 52 | 97 09 | 1908 | July 16..... | 10 30 | 13 61.2 | July 16..... | 10 30 | 78 15.0 | July 16..... | 13128 |
| | | | | " 17..... | | 58.8 | " 17..... | | 12.0 | " 17..... | |
| | | | | " 18..... | | 56.2 | " 18..... | | 11.9 | " 18..... | 13113 |
| | | | | " 20..... | | 57.1 | " 20..... | | | " 20..... | |
| Banff, Alta. | 51 10 | 115 37 | 1908 | July 22..... | | 26 6.8 | July 22..... | | 78 13.0 | | 13121 |
| | | | | " 23..... | | 5.7 | " 23..... | | | | |
| | | | | " 24..... | | 4.2 | " 24..... | | | | |
| | | | | | | | | | | | |
| Golden, B.C. | 51 18 | 116 57 | 1908 | July 27..... | | 26 5.6 | | | 74 58.1 | | 15855 |
| | | | | " 28..... | | 3.8 | | | | | |
| | | | | " 29..... | | 7.4 | | | 74 43.3 | July 27..... | 16152 |
| | | | | " 30..... | | 1.6 | | | 42.2 | " 28..... | 16167 |
| Revelstoke, B.C. | 51 0 | 118 12 | 1908 | Aug. 3..... | | 26 3.5 | | | 74 42.8 | " 29..... | 16160 |
| | | | | " 4..... | | | | | | " 30..... | |
| | | | | " 5..... | | | | | | | |
| | | | | | | | | | | | |
| Sicamous, B.C. | 50 50 | 118 59 | 1908 | Aug. 6..... | | 25 51.7 | Aug. 6..... | | 73 51.0 | Aug. 6..... | 16779 |
| | | | | " 7..... | | 55.3 | " 7..... | | 52.0 | " 7..... | |
| | | | | " 8..... | | 54.7 | " 8..... | | 52.0 | " 8..... | |
| | | | | | | | | | | | |

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| | | | | | | | | |
|---------------------|----|-----|----|------|-------------------------------------|---------------------------------|-----------------|----------------|
| Clinton, B.C. | 51 | 121 | 35 | 1908 | " 9. " 10. | 53.0 49.3 | " 9. " 10. | 16771 |
| | | | | | " 13. " 14. " 15. " 16. | 25 52.8 | 73 51.8 | 16775 |
| | | | | | Aug. 13. " 14. " 15. " 16. | 26 25.3 25.8 28.0 26.6 | 73 28.9 26.3 | 17040 17043 |
| | | | | | Aug. 22. " 23. " 24. | 26 26.4 | 73 27.6 | 17042 |
| Barkerville, B.C. | 53 | 121 | 30 | 1908 | Aug. 22. " 23. " 24. | 28 5.8 8.9 7.3 | 74 57.5 58.5 | 15707 15710 |
| | | | | | Aug. 26. " 27. " 28. | 28 7.3 | 74 58.0 | 15708 |
| | | | | | Aug. 26. " 27. " 28. | 28 18.1 19.1 19.9 | 74 51.3 50.8 | 15869 15857 |
| | | | | | Aug. 26. " 27. " 28. | 28 19.0 | 74 51.1 | 15863 |
| Alexandria, B.C. | 52 | 122 | 28 | 1908 | Aug. 30. " 31. Sept. 1. | 28 15.5 15.4 17.7 | 74 21.7 20.1 | 16401 16375 |
| | | | | | Aug. 30. " 31. Sept. 1. | 28 16.2 | 74 20.9 | 16388 |
| | | | | | Sept. 3. " 4. " 5. " 6. | 28 54.1 50.3 52.6 54.2 | 74 12.5 12.1 | 16524 16515 |
| | | | | | Sept. 3. " 4. " 5. " 6. | 28 52.8 | 74 12.3 | 16518 |
| Williams Lake, B.C. | 52 | 121 | 56 | 1908 | Sept. 8. " 9. | 26 49.0 45.8 | 73 35.0 35.2 | 17292 17142 |
| | | | | | Sept. 8. " 9. | 26 47.4 | 73 35.1 | 17172 |
| | | | | | Sept. 8. " 9. | | | |
| | | | | | Sept. 8. " 9. | | | |
| Bridge Creek, B.C. | 51 | 121 | 27 | 1908 | Sept. 8. " 9. | | | |
| | | | | | Sept. 8. " 9. | | | |
| | | | | | Sept. 8. " 9. | | | |
| | | | | | Sept. 8. " 9. | | | |

* Magnetic storm on afternoon of Sept. 4th.

** Observations for Dip were taken with Dover Dip Circle 145. The standards on Tesdorpf Magnetometer 1977 prevented a reading being taken.

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TABLE I—Continued.

| Place. | Latitude. | Longitude. | Year. | Month & day. | Hour & minute. | Declination. | Month & day. | Hour & minute. | Dip. | Month & day. | Hor. Intensity C. G. S. Units. |
|-----------------------|-----------|------------|-------|--------------------|----------------------|--------------|--------------------|----------------------|-------------------|--------------------|---|
| * Ashcroft, B.C. | 50 44 | 121 17 | 1908 | Sept. 11 | 10 30 | ..... | Sept. 11 | 10 30 | 73 { 25.6 24.9 | Sept. 11 | ..... |
| | | | | " 12 | ..... | ..... | " 12 | ..... | 26.2 | " 12 | ..... |
| | | | | " 14 | ..... | 27 46.8 | " 14 | ..... | { 28.4 25.6 | " 14 | 17214 |
| | | | | " 15 | ..... | 47.0 | " 15 | ..... | ..... | " 15 | 17229 |
| Spence's Bridge, B.C. | 50 25 | 121 21 | 1908 | Sept. 16 | ..... | 27 46.9 | Sept. 16 | ..... | 73 26.1 | Sept. 16 | 17222 |
| | | | | " 17 | ..... | ..... | " 17 | ..... | ..... | " 17 | 17379 |
| | | | | " 18 | ..... | 26 38.1 | " 18 | ..... | 72 59.3 | " 18 | 17361 |
| | | | | Sept. 16 | ..... | 40.6 | " 18 | ..... | 58.5 | " 18 | ..... |
| Nicola, B.C. | 50 9 | 120 40 | 1908 | Sept. 19 | ..... | 26 39.4 | Sept. 19 | ..... | 72 58.9 | Sept. 19 | 17270 |
| | | | | " 20 | ..... | ..... | " 20 | ..... | ..... | " 20 | 17546 |
| | | | | " 21 | ..... | 25 1.4 | " 21 | ..... | 72 54.7 | " 21 | 17546 |
| | | | | Sept. 19 | ..... | 4.1 | " 21 | ..... | 53.3 | " 21 | ..... |
| North Bend, B.C. | 49 52 | 121 27 | 1908 | Sept. 23 | ..... | 25 3.0 | Sept. 23 | ..... | 72 54.0 | Sept. 23 | 17546 |
| | | | | " 24 | ..... | ..... | " 24 | ..... | ..... | " 24 | ..... |
| | | | | " 25 | ..... | 25 48.6 | " 25 | ..... | 72 33.4 | " 25 | 17964 |
| | | | | " 26 | ..... | 48.9 | " 26 | ..... | 31.1 | " 26 | 17980 |
| ** Agassiz, B.C. | 49 15 | 121 45 | 1908 | Sept. 28 | ..... | 47.2 | Sept. 28 | ..... | ..... | Sept. 28 | 17972 |
| | | | | " 1 | ..... | 25 48.0 | " 1 | ..... | 72 32.1 | " 1 | ..... |
| | | | | " 2 | ..... | ..... | " 2 | ..... | ..... | " 2 | ..... |
| | | | | Sept. 28 | | 25 24.0 | Sept. 28 | | 71 34.9 | Sept. 28 | 18223 |
| | | | | Oct. 1 | | 23.2 | Oct. 1 | | 34.9 | Oct. 1 | 18915 |
| | | | | " 2 | | 25 23.6 | " 2 | | 71 34.9 | " 2 | 18919 |

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|----------------------------------|------|----|-----|----|----|----|------|----|------|--------|----|------|----|----|------|------|-------|------|----|----|------|------|-------|
| Vancouver, (Brockton Point) B.C. | 1908 | 7 | 123 | 18 | 49 | 5 | Oct. | 5 | 25 | 21 0 | 5 | Oct. | 5 | 6 | 71 | 39 5 | 18782 | Oct. | 5 | 6 | 71 | 41 4 | 18782 |
| | | | | | | 6 | " | 6 | 23 3 | | | " | 6 | | 44 0 | | 18781 | " | 6 | | 44 0 | | 18781 |
| | | | | | | 7 | " | 7 | 24 3 | | | " | 7 | | 42 8 | | 18782 | " | 7 | | 42 8 | | 18782 |
| | | | | | | 8 | " | 8 | 24 4 | | | " | 8 | | 41 7 | | 18769 | " | 8 | | 41 7 | | 18769 |
| | | | | | | | | | 25 | 23 3 | | | | | 71 | 42 4 | 18763 | | | | 71 | 42 4 | 18763 |
| Victoria, B.C. (C.I.S.) | 1908 | 21 | 123 | 25 | 48 | 12 | Oct. | 12 | 24 | 34 0 | 13 | Oct. | 12 | 13 | 71 | 18 3 | 18757 | Oct. | 12 | 13 | 71 | 18 3 | 18757 |
| | | | | | | 13 | " | 13 | 33 9 | | | " | 13 | | 19 8 | | 18769 | " | 13 | | 19 8 | | 18769 |
| | | | | | | 14 | " | 14 | 24 | 34 0 | | " | 14 | | 19 9 | | 18763 | " | 14 | | 19 9 | | 18763 |
| | | | | | | | | | 25 | 15 3 | | | | | 71 | 19 3 | 18827 | | | | 71 | 19 3 | 18827 |
| | | | | | | | | | 25 | 15 4 | 18 | Oct. | 17 | 18 | 71 | 19 3 | 18827 | Oct. | 17 | 18 | 71 | 19 3 | 18827 |
| Ottawa, Ont. (C.I.S.) | 1908 | 43 | 75 | 24 | 45 | 2 | Nov. | 2 | 12 | 49 1 W | 5 | Nov. | 2 | 3 | 75 | 41 9 | 15150 | Nov. | 2 | 3 | 75 | 41 9 | 15150 |
| | | | | | | 3 | " | 3 | 47 5 | | | " | 3 | | 48 9 | | 15169 | " | 3 | | 48 9 | | 15169 |
| | | | | | | 26 | " | 26 | 12 | 48 5 W | | " | 26 | | 75 | 41 9 | 15156 | " | 26 | | 75 | 41 9 | 15156 |
| | | | | | | | | | 12 | 50 3 | | | | | 75 | 41 9 | 15156 | | | | 75 | 41 9 | 15156 |
| | | | | | | | | | 12 | 50 2 | | | | | 75 | 41 9 | 15156 | | | | 75 | 41 9 | 15156 |
| Ottawa, Ont. (Hut.) | 1908 | 43 | 75 | 24 | 45 | 20 | Nov. | 20 | 12 | 50 3 | 23 | Nov. | 20 | 23 | 75 | 41 9 | 15156 | Nov. | 20 | 23 | 75 | 41 9 | 15156 |
| | | | | | | 26 | " | 26 | 12 | 50 2 | 26 | " | 26 | 26 | 75 | 41 9 | 15156 | " | 26 | 26 | 75 | 41 9 | 15156 |
| | | | | | | 27 | " | 27 | 12 | 50 5 W | | " | 27 | | 75 | 41 9 | 15156 | " | 27 | | 75 | 41 9 | 15156 |
| | | | | | | | | | 12 | 50 5 W | | | | | 75 | 41 9 | 15156 | | | | 75 | 41 9 | 15156 |
| | | | | | | | | | 12 | 50 5 W | | | | | 75 | 41 9 | 15156 | | | | 75 | 41 9 | 15156 |

* Magnetic storm Sept. 11th and 12th. Aurora Sept. 11th.
 ** Magnetic storm Sept. 29th and 30th. Aurora Sept. 29th.

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TABLE II.

This table gives a resume of Table I, together with the values of the horizontal intensity observed with Dover 145.

1977—Tesdorpf Magnetometer.
145—Dover Dip Circle.

| Place. | Latitude. | Longitude. | Year. | Month & day. | Declination. | Month & day. | Dip. | Month & day. | Hor. force C.G.S. Units. | Instrument. |
|---|-----------|------------|-------|---------------|--------------|-----------------------|-----------------|--------------------|--------------------------|-------------|
| Winnipeg, Man., Carnegie Instit't'n Stn | 49 52 | 97 9 | 1908 | July 16-20 | 13 58.6 | July 17-18-20 " 17 | 78 13-0 13-0 | July 16-18 " 17 | .13121 .13060 | 1977 145 |
| Banff, Alta., Carnegie Institution Stn | 51 10 | 115 37 | ..... | " 22-24 | 26 5.6 | " 23-24 " 25 | 74 58.1 59.3 | " 22-24 " 25 | .15955 .15942 | 1977 145 |
| Golden, B.C. | 51 18 | 116 57 | ..... | " 27-30 | 26 3.5 | " 27-29 " 28 | 74 42.8 40.1 | " 27-29 " 28 | .16190 .16142 | 1977 145 |
| Revelstoke, B.C. | 51 0 | 118 12 | ..... | Aug 3-4-5 | 25 48.6 | Aug. 1-3-4 " 5 | 74 16.1 16.6 | Aug. 1-3-4 " 5 | .16501 .16458 | 1977 145 |
| Squamish, B.C. | 50 50 | 118 59 | ..... | " 6-10 | 25 59.8 | " 6-7-8 " 10 | 73 51.8 55.4 | " 6-9 " 10 | .16775 .16785 | 1977 145 |
| Clinton, B.C. | 51 6 | 121 35 | ..... | " 13-16 | 26 26.4 | " 14-15 " 13 | 73 27.6 25.1 | " 14-15 " 13 | .17042 .17223 | 1977 145 |
| Barkerville, B.C. | 53 4 | 121 30 | ..... | " 22-24 | 28 7.3 | " 22-23 " 21 | 74 58.0 57.6 | " 22-23 " 21 | .15708 .15694 | 1977 145 |
| Queensland, B.C. | 52 59 | 122 32 | ..... | " 26-28 | 28 19.0 | " 26-27 " 28 | 74 51.1 49.0 | " 26-27 " 28 | .15863 .15913 | 1977 145 |
| Alexandria, B.C. | 52 35 | 122 28 | ..... | Aug 30-Sept 1 | 28 16.2 | " 30-31 Sept. 1 | 74 20.9 18.4 | " 30-31 Sept. 1 | .16388 .16168 | 1977 145 |
| *Williams Lake, (150 mile post) B.C. | 52 6 | 121 56 | | Sept. 3-5 | 28 52.8 | " 3-5 " 5 | 74 12.3 12.4 | " 3-5 " 5 | .16318 .16507 | 1977 145 |
| Bridge Creek, (100 mile post) B.C. | 51 39 | 121 27 | | " 8-9 | 26 47.4 | " 8-9 | 73 35.1 | " 8-9 | .17172 | 1977 |

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|---|----|----|-----|----|-------|------|----------|----|-------|------------|-----------|-------|-------|------------|-------|-------|------|
| Ashcroft, B.C., Carnegie Institution Sta. | 50 | 44 | 121 | 17 | | " | 11-15 | 27 | 45.5 | " | 11-12-14 | 73 | 26.1 | " | 14-15 | 17222 | 1977 |
| | | | | | | | | | | | " | 26.8 | 26.8 | " | 12 | 17208 | 145 |
| Spence's Bridge, B.C. | 50 | 25 | 121 | 21 | ..... | " | 17-18 | 26 | 39.4 | " | 17-18 | 72 | 58.9 | " | 16-17 | 17370 | 1977 |
| | | | | | | | | | | | " | 57.6 | 57.6 | " | 18 | 17414 | 145 |
| Nicola, B.C. | 50 | 9 | 120 | 40 | ..... | " | 19-21 | 25 | 3.0 | " | 19-20 | 72 | 54.0 | " | 19-20 | 17546 | 1977 |
| | | | | | | | | | | | " | 53.4 | 53.4 | " | 21 | 17529 | 145 |
| North Bend, B.C. | 49 | 52 | 121 | 27 | ..... | " | 23-26 | 25 | 48.0 | " | 23-25 | 72 | 32.1 | " | 24-25 | 17972 | 1977 |
| | | | | | | | | | | | " | 31.2 | 31.2 | " | ..... | 17946 | 145 |
| †Agassiz, B.C. | 49 | 15 | 121 | 45 | ..... | Oct. | 1-2 | 25 | 23.6 | Sept. 28 | Oct. 1, 2 | 71 | 34.9 | Oct. | 1, 2 | 18919 | 1977 |
| | | | | | | | | | | | " | 36.1 | 36.1 | Sept. | 28 | 18902 | 145 |
| Vancouver, B.C., (Brookton Point) | 49 | 18 | 123 | 7 | ..... | " | 5-8 | 25 | 23.3 | Oct. | 6-8 | 71 | 42.4 | Oct. | 7-8 | 18782 | 1977 |
| | | | | | | | | | | | " | 43.7 | 43.7 | " | 3 | 18669 | 145 |
| Victoria, B.C., Carnegie Institution Sta. | 48 | 25 | 123 | 21 | ..... | " | 13-14 | 24 | 34.0 | " | 12-14 | 71 | 19.3 | " | 13-14 | 18763 | 1977 |
| | | | | | | | | | | | " | 17.0 | 17.0 | " | 10 | 18779 | 145 |
| Nanaimo, B.C., (Jesse Island) | 49 | 13 | 123 | 52 | ..... | " | 17-18 | 25 | 15.3 | " | 17-18 | 71 | 20.2 | " | 17 | 18827 | 1977 |
| | | | | | | | | | | | " | 21.5 | 21.5 | " | 18 | 18786 | 145 |
| Ottawa, Ont., Carnegie Institution Sta. | 45 | 24 | 75 | 43 | ..... | Nov. | 2-5 | 12 | 48.5W | Nov. | 2 | 75 | 41.9 | " | 2-3 | 15156 | 1977 |
| | | | | | | | | | | | | | | | | | |
| Ottawa, Ont., (Hut) | 45 | 24 | 75 | 43 | ..... | " | 20-23-26 | 12 | 50.5W | Nov. 23-27 | ..... | ..... | ..... | Nov. 23-27 | ..... | 15157 | 1977 |

* Magnetic storm Sept. 4th, p.m.

† " " " Sept. 11th and 12th, Aurora, Sept. 11th.

‡ " " " Sept. 11th and 12th, " 2nd.

§ The "Dip" at Winnipeg was obtained with Dover Dip Circle 145.

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In the report of 1898 the Department of the Interior published the magnetic data that had been obtained in connection with the survey and exploration of Dominion lands between the years 1881 and 1890. The declination was generally obtained by means of a long compass needle attached to the lower plate of a transit-theodolite within a narrow box, fitting into a groove, while inclination and total force (intensity) were obtained by a Kew Dip Circle, the constants of which had been determined at the Toronto Magnetic Observatory.

The observations extended in latitude from Port Arthur $48^{\circ} 26'$ to Lake Lindeman $59^{\circ} 47'$ near the head waters of the Yukon, and in longitude from Eastmain, $78^{\circ} 29'$, to Lake Lindeman, $135^{\circ} 05'$. The number of stations distributed over this vast area was 204, but by no means uniformly distributed, the most of them lying along exploratory routes.

In 1883 Sir J. H. Lefroy published his observations in Canada made in 1843-44, covering 314 stations.

These two publications are the only ones up to the present of extended magnetic observations in Canada, except the publications of the United States Coast and Geodetic Survey, which are partly based on the above data and partly on the observations by officers of that survey.

It is thought desirable to bring together the whole of the magnetic data available in our office and publish it.

For the present it is considered more desirable to publish the actual observations than to defer until a reduction has been made to a uniform epoch. The data for most of the stations and many areas, are far too limited to justify such a reduction by themselves. The principal difficulty encountered in reducing to a common epoch, or in reducing from one epoch to another is that of secular variation. Although the existence of secular variation has been known since the days of Gellibrand, 275 years ago, yet its explanation is still unknown. Here is a case where nature absolutely refuses to allow itself to be put in a straight jacket of mathematical formulae, but instead, pursues its apparently erratic course to the dismay of investigators. As Huxley has well said, that 'our mathematical skill is no guarantee of the quality of the grist,' adding that, 'as the grandest mill will not extract wheat flour from peascods, so pages of formulae will not get a definite result out of loose data.'

The element, for which for practical purposes, information is from time to time required is the declination, due to the fact that nearly all the older surveys were made with chain and compass, so that in re-tracing or re-establishing an old survey line it is frequently necessary to know the amount of change of the position of the needle, in short, the secular variation for the interval of time. It is impossible to give a general formula from which to deduce the information desired. However, as the original compass survey was at best but an approximation, the secular variation deduced from some empirical formula covering the area under consideration will furnish data for the re-establishment of old survey lines run by compass with a degree of accuracy quite in keeping with the bearing of the original line. The application of secular variation is most applicable in the re-survey of 'timber limits,' where seldom a definite line of reference is available, of which the magnetic bearing at the time of the timber limit survey is given. Such limits generally border a stream or river, the direction of the other sides was mostly made dependent upon the general course or trend of the river. What was accepted at the time by the surveyor as the general course of the river it is impossible subsequently to determine, so that laying off angles with a transit from the river is out of the question, and we fall back on the compass line as corrected for secular variation for re-determining the boundaries of an old timber limit.

For the re-establishment of lot lines in eastern Canada, which was originally almost completely wooded, and where the original surveys were all made by chain and compass, the ease is somewhat different. Here 'concessions' and 'side-roads' were

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the governing factors for the directions of the lot lines, and these former ones were the ones to be opened up first, before the blazes and marks of the original survey were lost and obliterated. Hence in re-running a lot line at present with a compass, one would need only observe the actual magnetic bearing of the governing concession line and apply the difference between it and its original bearing, to the original bearing of the lot line for obtaining its present magnetic direction. Nowadays, however, no surveyor's outfit in Canada is confined to a compass, in fact this instrument on Jacob's staff is obsolete, and the transit-theodolite is used, with which the proper angle would be turned off from the governing line for the lot line irrespective of the magnetic bearing of either.

There are other cases besides those of timber limits and original lot lines. These refer to subdivision lines abutting on original lot lines or other subdivision lines, all run at different periods, the maps thereof showing the magnetic bearing for each line when surveyed, which for a closed figure is, on the face of it, a mathematical impossibility. Such cases, personally well known to the writer, tax the ingenuity and skill of the surveyor, armed with theodolite, compass, secular variation, 'deeds' and plans, to do justice to all parties and lines concerned. It may be noted that while the secular variation in general is but a few minutes per year, the daily or diurnal variation is several times that amount. This indicates the importance of noting the time of day when an observation for declination is taken. A disregard of this precaution is equivalent to probably several years displacement theoretically of the year of observation. Conversely, most of our old survey data do not include the time of day when the direction of a line had a certain magnetic bearing, hence with meagre data with reference to different periods or years for a given place, as is the case for many of the stations hereafter given, it is obvious that in the attempt to deduce secular variation therefrom or a general expression for the declination at a given time, we cannot hope to attain more than a rude approximation; much more so when we wish to carry the determination beyond the limits of observation, that is, when we extrapolate instead of interpolate.

The diurnal variation reaches its extreme value eastward at about 8 a.m. and westward at about 1.30 p.m., crossing the average magnetic meridian for the place at about 10.30 a.m. This applies to the southerly part of Canada; in the higher latitudes, the time interval of elongation from the magnetic meridian is increased.

Stations.

In the grouping of our stations, lying between the Atlantic and Pacific oceans and extending to Hudson bay and the Arctic ocean, it was considered more desirable to group them by political divisions as far as possible, *i.e.*, by provinces, than to bound the groups by parallels of latitude and meridians of longitude. In any case we will have contiguous stations falling into different groups. To the general public, to the surveyor, the engineer, the grouping by provinces will be more acceptable than any other scheme.

Canada has hence been divided into the following groups:—

Quebec and Labrador; Nova Scotia, including Cape Breton and Prince Edward Island; Ontario; Hudson bay and surrounding territory; Manitoba; Saskatchewan and Alberta; British Columbia; and Yukon and Northwest Territories, these latter extending from the 60th parallel to the Arctic ocean and west of Hudson bay.

In each of these groups the stations have been arranged in order of longitude, so that, in general, the tabulation will show, considering west declination positive and east declination negative, an algebraic decrease of declination with an increase of longitude.

The agonic line, or line 'without an angle,' *i.e.*, the line joining the points at which the direction of the magnetic meridian is coincident with that of the astronomic

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meridian, passes at the present time somewhat to the west of Schreiber on the Canadian Pacific Railway, and west of Windsor. Places to the east of it have west declination, and those to the west have east declination.

In the table of compiled magnetic elements,—declination, inclination, horizontal and total intensities,—the column 'Observer' gives the source of the information, indicated by abbreviation, when the observer himself is not given.

The data opposite to the abbreviations C.I., C.S. and L.S., are taken from

TABLE
MAGNETIC

NOVA

C. I.—Carnegie Institution.

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--------------------------------|-----------|------------|--------|-------------------|------------------------|--------------|
| | ° ' " | ° ' " | | | | ° ' " |
| Louisburg. | 45 53.0 | 60 00.0 | 1862 | | | |
| Cape Breton. | 46 16.0 | 60 08.0 | 1862 | | | |
| Sydney, Cape Breton. | 46 09.0 | 60 11.0 | 1905.5 | | | 24 48 W |
| " " | 46 08.6 | 60 11.6 | 1881 | Oct. 21, 22. | | 25 11.8 " |
| " " | 46 08.5 | 60 11.8 | 1896 | July 11, 13. | | 24 53.4 |
| " " | 46 06.7 | 60 12.0 | 1907 | Oct. 30, 31. | | 25 27.9 |
| " " | | | | Nov. 1, 2. | | |
| " " | 46 09.0 | 60 15.0 | 1905.7 | | | 25 09.6 " |
| Arichat, Isle Madame. | 45 30.5 | 61 01.3 | 1881 | Oct. 26 | | 23 25.9 " |
| Isle Madame, Cape Breton. | 45 28.0 | 61 03.0 | 1862 | | | |
| Mulgrave. | 45 35.1 | 61 22.5 | 1907 | Nov. 5, 6. | | 24 13.2 |
| Antigonish. | 45 35.6 | 61 59.2 | 1907 | " 8, 9. | | 23 25.4 |
| Pictou. | 45 38.0 | 62 43.5 | 1907 | Oct. 25, 26, 28. | | 23 01.9 |
| Truro. | 45 20.2 | 63 15.0 | 1907 | " 22, 23, 24. | | 21 50.7 |
| Point Pleasant. | 44 37.0 | 63 34.0 | 1904.7 | | | 21 02.0 " |
| " | " | " | 1905.7 | | | 20 47.3 " |
| Halifax. | 44 40.0 | 63 35.0 | 1834 | | | |
| " | " | " | 1837 | | | |
| " | " | " | 1838.5 | | | |
| " | " | " | 1847.5 | | | |
| " | " | " | 1873 | | | |
| " | " | " | 1879 | Sept. 8-10. | | 20 43.3 " |
| " | " | " | 1881 | | | |
| " | 44 39.5 | 63 35.0 | 1896 | July 6, 7. | | 20 38.6 " |
| Pugwash. | 45 50.2 | 63 40.5 | 1907 | Oct. 19, 20, 21. | | 22 39.0 |
| Black Point. | 44 38.0 | 64 01.0 | 1905.7 | | | 21 01.0 " |
| Windsor. | 44 59.6 | 64 08.4 | 1847 | | | |
| " | 44 59.6 | 64 08.4 | 1881 | Nov. 22. | | 20 42.3 " |
| Kentville. | 45 12.0 | 64 46.0 | 1847 | | | |
| Annapolis. | 44 44.5 | 65 31.1 | 1881 | Nov. 14, 15, 16. | | 19 26.8 " |
| Weymouth. | 44 24.4 | 65 59.8 | 1881 | " 11. | | 18 43.4 " |
| Yarmouth. | 43 49.9 | 66 07.2 | 1881 | " 7, 8. | | 17 49.4 " |

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'United States Magnetic Tables and Magnetic Charts for 1905,' by L. A. Bauer, and published by the United States Coast and Geodetic Survey, 1908.

C.I. refers to observations made by officers of the Carnegie Institution.

C.S. refers to observations made or published by the United States Coast and Geodetic Survey.

L.S. refers to observations by the United States Lake Survey.

III.

RESULTS.

SCOTIA.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature. | Observer. |
|-----------------|------------------|---------|-----------------|------------------|--------------|---------------|--------------|-----------------------|
| | | 76 00.0 | | | | | | Shadwell. |
| | | 76 03.0 | | | | | | " |
| | | 74 25.0 | | | 1560 | | | French Navy. |
| Oct. 21, 22. | | 75 10.0 | Oct. 21, 22. | | | 5918 | | S. W. Very. |
| | | 74 38.6 | | | 1547 | 5842 | | G. R. Putnam. |
| | | 74 16.8 | | | 1563 | 5768 | | White-Fraser. |
| | | 74 23.7 | | | 1566 | | | C. I. |
| Oct. 26. | | 74 43.0 | Oct. 26. | | | 6007 | | S. W. Very. |
| | | 75 31.0 | | | | | | Shadwell. |
| | | 73 53.6 | | | 1611 | 5807 | | White-Fraser. |
| | | 74 17.9 | | | 1596 | 5899 | | " |
| | | 74 31.2 | | | 1577 | 5910 | | " |
| | | 73 52.5 | | | 1618 | 5827 | | " |
| | | 73 58.0 | | | 1624 | | | N. S. Instit. Science |
| | | 73 59.6 | | | 1619 | | | C. I. |
| | | 75 33.0 | | | | 5966 | | E. Home. |
| | | 74 58.0 | | | | | | " |
| | | 74 45.0 | | | | | | Estcourt. |
| | | 75 37.0 | | | | 6026 | | Keily. |
| May 13, 15, 16. | | 74 48.2 | May 13, 15, 16. | | | 5954 | | Maclean & Bromley |
| Sept. 8-10. | | 74 39.2 | Sept. 8-10. | | | 6013 | | J. B. Baylor. |
| Nov. 2. | | 74 29.0 | Nov. 2. | | | 5902 | | S. W. Very. |
| | | 73 54.0 | | | 1632 | 5885 | | G. R. Putnam. |
| | | 74 48.8 | | | 1544 | 5895 | | White-Fraser. |
| | | 73 59.9 | | | 1617 | | | C. I. |
| | | 75 41.0 | | | | | | G. W. Keily. |
| Nov. 21, 22. | | 74 49.0 | Nov. 21, 22. | | | 6026 | | S. W. Very. |
| | | 75 46.0 | | | | | | G. W. Keily. |
| | | 74 53.0 | Nov. 14, 15. | | | 6059 | | S. W. Very. |
| Nov. 10. | | 74 45.0 | Nov. 10. | | | 6058 | | " |
| " 7. | | 74 33.0 | Nov. 8. | | | 6026 | | " |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC

QUEBEC—

C. I.—Carnegie Institution.
C. S.—Coast Survey.

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--|-----------|------------|--------|-----------------------------|------------------|--------------|
| Battle Harbour, Caribou is- land, Labrador..... | 52 16.3 | 55 34.5 | 1881 | Sept. 5,6,7,8. | | 37 12.7W |
| Grady, Labrador..... | 53 48.2 | 56 25.3 | 1881 | Aug. 3,4..... | | 39 03.8 " |
| Turnavik, Labrador..... | 55 14.9 | 59 19.0 | 1881 | July 28,29..... | | 40 22.8 " |
| " "..... | 55 14.6 | 59 20.3 | 1896 | July 20..... | | 38 26.4 " |
| Nain, Labrador..... | 56 32.7 | 61 40.7 | 1881 | Aug. 11 to 18 | | 44 50.2 " |
| Gaspé Basin..... | 48 50.0 | 64 30.0 | 1832 | | | |
| Rivière du Loup..... | 47 51.0 | 69 25.0 | 1876 | | | |
| " "..... | 47 50.0 | 69 33.0 | 1906 7 | | | 20 38.7W |
| Brandyot island..... | 47 53.0 | 69 42.0 | 1830 | | | |
| St. Thomas, Montmagny..... | 46 59.0 | 70 33.0 | 1876 | Aug. 24,25..... | | 17 50.1W |
| Megantic..... | 45 34.4 | 70 53.2 | 1907 | Sept. 20,21, 23, 24..... | | 16 33.2 " |
| Alphonse..... | 48 21.0 | 70 54.0 | 1906 7 | | | 21 54.0 " |
| Tring Jct..... | 46 15.5 | 71 00.0 | 1907 | Sept. 26, 27..... | | 17 22.2 " |
| Chicoutimi..... | 48 25.0 | 71 03.0 | 1906 7 | | | 20 17.1 " |
| Quebec..... | 46 48.6 | 71 13.3 | 1845 | | | |
| " "..... | 46 " | 71 " | " | | | |
| " "..... | 46 48.0 | 71 14.0 | 1906 2 | | | 17 53.0W |
| " "..... | 46 49.5 | 71 14.2 | 1842 | Sept. 1..... | | 14 12.0 " |
| " "..... | 46 48.4 | 71 14.5 | 1839 | July 19..... | | 16 17.0 " |
| " "..... | " | " | 1879 | Sept. 16, 19..... | | 17 13.7 " |
| Bécancour..... | 46 22.0 | 71 33.0 | 1876 | Aug. 17,18..... | | 15 43.5 " |
| Sherbrooke..... | 45 23.9 | 71 56.2 | 1907 | Sept. 14,16, 17, 18..... | | 15 59.9 " |
| Richmond Jct..... | 45 41.0 | 72 03.0 | 1876 | Aug. 15..... | | 16 59.6 " |
| Peribonka..... | 48 46.0 | 72 05.0 | 1906 7 | | | 20 55.7 " |
| Stanstead..... | 45 02.0 | 72 07.0 | 1842 | | | |
| Kingsley..... | 45 46.0 | 72 12.0 | 1842 | | | |
| Roberval..... | 48 31.0 | 72 14.0 | 1906 7 | | | 19 44.5W |
| Mistassini..... | 48 54.0 | 72 14.0 | 1906 7 | | | 19 20.5 " |
| Lake Membrenagog..... | 45 01.0 | 72 15.0 | 1845 | | | |
| Lake Edward..... | 47 40.0 | 72 15.0 | 1906 7 | | | 19 34.4W |
| Three Rivers..... | 46 21.0 | 72 32.0 | 1842 | | | |
| " "..... | 46 21.0 | 72 33.0 | 1906 7 | | | 15 26.1W |
| Farnham..... | 45 16.1 | 73 01.5 | 1907 | Sept. 9,10,11..... | | 15 12.4 " |
| Sorel..... | 46 02.0 | 73 03.0 | 1842 | | | |
| " "..... | " | " | " | | | |
| St. Johns..... | 45 17.0 | 73 15.0 | 1842 | | | |
| Montreal..... | 45 31.0 | 73 30.0 | 1833 | | | |
| St. Helens island, Montreal..... | 45 31.1 | 73 31.7 | 1842 | Sept. 19..... | 8 31a | 8 57.6W |
| " " " "..... | " | " | 1843 | | | |
| " " " "..... | " | " | " | | | |
| " " " "..... | " | " | " | | | |
| Montreal, The Mountain..... | 45 31.0 | 73 33.3 | 1845 | | | |
| Montreal..... | 45 31.0 | 73 32.0 | 1843 | | | |
| " "..... | 45 30.0 | 73 33.0 | 1838 | | | |
| " "..... | 45 30.3 | 73 34.9 | 1839 | July 20..... | | 12 21.0W |
| " "..... | " | " | 1879 | Sept. 25..... | | 13 40.5 " |
| " "..... | " | 73 35.0 | 1896 8 | | | 14 19.0 " |
| " "..... | " | " | 1905 7 | | | 14 40.1 " |
| " "..... | " | " | 1906 7 | | | |

SESSIONAL PAPER No. 25a

IV.

RESULTS.

LABRADOR.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature. | Observer. |
|------------------|------------------|---------|------------------|------------------|--------------|---------------|--------------|------------------|
| Sept. 6, 7, 8, 9 | | 77 16.0 | Sept. 6, 7, 8. | | | 5794 | | S. W. Very. |
| Aug. 3, 4, 5. | | 77 49.0 | Aug. 3, 4. | | | 6060 | | " |
| July 28, 29. | | 79 56.0 | July 28, 29. | | | 5916 | | " |
| | | 79 30.8 | | | 1074 | 5901 | | G. R. Putnam. |
| Aug. 11, 14, 19. | | 78 22.0 | Aug. 11, 15, 19. | | | 5961 | | S. W. Very. |
| | | 78 50.0 | | | | 5952 | | Capt. Bayfield. |
| Aug. 23, 30. | | 77 31.6 | | | | 1408 | | F. E. Hilgard. |
| | | 76 34.1 | | | | | | C. I. |
| | | | | | | | | Capt. Bayfield. |
| Aug. 24, 25. | | 77 11.7 | | | | 5952 | | F. E. Hilgard. |
| | | 75 40.6 | | | 1498 | 6056 | | White-Fraser. |
| | | 77 56.1 | | | 1279 | | | C. I. |
| | | 76 06.7 | | | 1462 | 6094 | | White-Fraser. |
| | | 77 36.9 | | | 1334 | | | C. I. |
| | | 77 08.8 | June 23. | | | 6286 | | C. Younghusband. |
| | | | " 23. | | | 6284 | | " |
| | | 76 01.1 | | | 1477 | | | C. I. |
| Sept. 1. | | 77 15.3 | Sept. 1. | | | 6383 | | J. H. Lefroy. |
| July 18. | | 77 17.5 | July 19. | | | 6271 | | Schott. |
| Sept. 16, 19. | | 76 45.1 | Sept. 16, 19. | | | 6243 | | Baylor. |
| Aug. 17, 18. | | 76 54.5 | Aug. 17, 18. | | | 6005 | | F. E. Hilgard. |
| | | 75 26.7 | | | 1512 | 6018 | | White-Fraser. |
| Aug. 15. | | 75 47.7 | Aug. 15. | | | 6009 | | F. E. Hilgard. |
| | | 77 27.4 | | | 1328 | | | C. I. |
| Sept. 12. | | 77 19.2 | Sept. 12. | | | 6282 | | J. H. Lefroy. |
| Sept. 10. | | 77 14.0 | " 10. | | | 6311 | | " |
| | | 77 33.5 | | | 1329 | | | C. I. |
| | | 78 19.4 | | | 1250 | | | " |
| | | 76 08.6 | | | | | | A. W. Whipple. |
| | | 76 54.2 | | | 1389 | | | C. I. |
| Sept. 6. | | 77 10.7 | Sept. 6. | | | 6383 | | J. H. Lefroy. |
| | | 75 57.1 | | | 1482 | | | C. I. |
| | | 75 20.1 | | | 1540 | 6095 | | White-Fraser. |
| Sept. 8. | | 77 16.4 | Sept. 8. | | | 6340 | | J. H. Lefroy. |
| " 8. | | 77 16.5 | | | | | | " |
| " 14. | | 77 00.1 | | | | | | " |
| | | 77 06.0 | | | | | | Back. |
| Sept. 16. | | 77 13.1 | | | | 6326 | | J. H. Lefroy. |
| April 25. | | 77 15.7 | April 25. | | | 6362 | | " |
| " 28. | | 77 02.1 | " 28. | | | 6356 | | " |
| " 29. | | 77 08.6 | " 29. | | | 6317 | | " |
| June 20. | | 77 06.7 | June 20. | | | 6248 | | C. Younghusband. |
| " 20. | | 77 10.3 | " 23. | | | 6234 | | " |
| | | | August. | | | 6280 | | A. D. Bache. |
| | | 76 19.0 | | | | | | Estcourt. |
| July 20. | | 76 51.4 | July 20. | | | 6308 | | Schott. |
| Sept. 25. | | 76 25.7 | Sept. 25. | | | 6271 | | Baylor. |
| | | 75 40.2 | | | 1507 | | | C. S. |
| | | 75 38.2 | | | 1512 | | | C. I. |
| | | 75 38.1 | | | | | | " |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC

QUEBEC—

C. I.—Carnegie Institution.
C. S.—Coast Survey.

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|-------------------------------|-----------|------------|--------|----------------------|------------------------|--------------|
| *Isle Dorval..... | 45 25 0 | 73 44 0 | 1843 | | | |
| " | " | " | " | | | |
| St. Jérôme..... | 45 46 0 | 73 59 0 | 1906 7 | | | 15 49 2W |
| Lacombe farm..... | 55 33 0 | 74 09 0 | 1843 3 | | | 8 26 0 " |
| Labelle..... | 46 16 0 | 74 33 0 | 1906 7 | | | 15 24 6 " |
| *Pointe du Chêne..... | 45 37 0 | 74 50 0 | 1843 | May 3 | 6 40p | 7 28 0 " |
| " | " | " | " | | | |
| *Mishomis..... | 47 13 0 | 75 38 0 | 1906 8 | | | 18 15 3W |
| Baskatong..... | 46 49 0 | 75 52 0 | 1906 8 | | | 12 16 2 " |
| Aylmer..... | 45 15 0 | 75 58 0 | 1843 | | | |
| Maniwaki..... | 46 23 0 | 75 59 0 | 1906 7 | | | 12 20 0W |
| *Portage des Chats..... | 45 26 0 | 76 32 0 | 1843 | | | |
| " | " | " | " | | | |
| Portage du Grand Calumet.... | 45 45 0 | 76 40 0 | 1843 | | | |
| Fort Coulonge..... | 45 54 9 | 76 45 0 | 1843 | | | |
| " | " | " | " | | | |
| Pointe Baptême..... | 46 05 0 | 77 26 0 | 1843 | | | |
| Portage des Deux-Joachims.... | 46 12 1 | 77 40 0 | 1843 | | | |
| " | " | " | " | | | |
| Trou portage..... | 46 15 0 | 78 16 0 | 1843 | | | |
| " | " | " | " | | | |
| Kipawa..... | 46 47 0 | 78 59 0 | 1906 8 | | | 9 44 9W |

* Local disturbance.

SESSIONAL PAPER No. 25a

IV—*Con.*RESULTS—*Con.*LABRADOR—*Con.*

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|---------------|
| April 30. | p. m. | 77 03.1 | April 30. | | | 6302 | | J. H. Lefroy. |
| | | | " 30. | | | 6297 | | " |
| | | | " 30. | | | 6261 | | " |
| | | 76 08.2 | | | 1487 | | | C. I. |
| | | 76 50.6 | | | 1454 | | | J. H. Lefroy. |
| | | 76 29.8 | | | 1432 | | | C. I. |
| May 3. | | 76 55.4 | May 3. | | | 6273 | | J. H. Lefroy. |
| | | | " 3. | | | 6302 | | " |
| | | 77 04.2 | | | 1392 | | | C. I. |
| | | 76 38.5 | | | 1417 | | | " |
| May 5. | | 76 41.0 | May 5. | | | 6380 | | J. H. Lefroy. |
| | | 76 29.5 | | | 1441 | | | C. I. |
| May 6. | Noon. | 75 07.0 | May 6. | | | 6450 | | J. H. Lefroy. |
| | | | " 6. | | | 6399 | | " |
| May 7. | p. m. | 76 44.4 | " 7. | | | 6378 | | " |
| " 8. | p. m. | 77 29.7 | " 8. | | | 6418 | | " |
| " 8. | | 77 16.7 | " 8. | | | 6415 | | " |
| | | | " 8. | | | 6433 | | " |
| May 9. | 3 00p | 77 19.1 | " 9. | | | 6351 | | " |
| " 10. | 11 00a | 77 03.8 | " 10. | | | 6374 | | " |
| | | | " 10. | | | 6383 | | " |
| May 11. | p. m. | 77 24.4 | " 11. | | | 6429 | | " |
| | | | " 11. | | | 6403 | | " |
| | | 76 41.8 | | | 1430 | | | C. I. |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC

C. I.—Carnegie Institution.

L.S.—Lake Survey.

C.S.—Coast Survey.

ONTA

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--------------------------------|-----------|------------|--------|----------------|------------------|--------------|
| | " " | " " | | | | " " |
| Hawkesbury | 45 36.0 | 74 37.0 | 1906-7 | | | 11 51.3 W |
| Cornwall | 45 02.0 | 74 50.0 | 1845 | | | |
| " | " | " | " | | | |
| Williamsburg | 44 55.0 | 75 07.0 | 1843 | | | |
| " | " | " | " | | | |
| Fox Point, Ottawa river | 45 32.0 | 75 22.0 | 1843 | | | |
| " | " | " | " | | | |
| Prescott | 44 35.0 | 75 30.0 | 1843 | | | |
| Brockville | 44 35.9 | 75 40.7 | 1907 | Sept. 2, 3, 4. | | 10 54.3 |
| " | 44 32.0 | 75 41.0 | 1845 | | | |
| " | " | " | " | | | |
| Ottawa | 45 21.0 | 75 42.0 | 1856 | | | |
| " | 45 23.6 | 75 42.9 | 1907 | June 3. | | 12 36.5 |
| " (C. I. S.) | 45 24.0 | 75 43.0 | 1908 | Nov. 2, 5, 26 | | 12 48.5 W |
| " (Magnetic hnt) | " | " | " | " 20, 23, 26 | | 12 50.5 " |
| Kingston Jet | 44 15.2 | 76 28.0 | 1907 | Aug. 27, 28 | | 14 16.9 " |
| " (R. M. College*) | 44 13.8 | 76 28.2 | " | " 20, 21. | | 36 46.4 |
| " (Artillery Barracks*) | 44 13.0 | 76 28.6 | 1842 | | | |
| " | " | " | " | | | |
| " | " | " | 1843 | | | |
| " | " | " | " | | | |
| " | " | " | 1845 | | | |
| Kingston (Stewart point) | 44 12.0 | 76 29.0 | " | | | |
| " | " | " | " | | | |
| Kingston (Barracks) | 44 13.0 | 76 29.2 | 1907 | Aug. 25 | | *30 07.4 |
| Kingston Junction | 44 15.0 | 76 29.0 | 1906-7 | | | 13 26.0 W |
| Kingston (The Common) | 44 13.0 | 76 30.0 | 1845 | | | |
| " | " | " | " | | | |
| Renfrew | 45 29.0 | 76 40.0 | 1906-7 | | | 11 13.6 W |
| Sharbot lake | 44 46.4 | 76 41.2 | 1907 | | | 11 28.7 |
| Pembroke | 45 49.3 | 77 07.5 | " | | | 10 16.7 |
| Belleville | 44 09.0 | 77 25.0 | 1843 | | | |
| Chalk river | 46 00.0 | 77 26.0 | 1906-8 | | | 10 20.2 W |
| Barry bay | 45 28.8 | 77 40.3 | 1907 | Aug. 9. | | 08 46.3 |
| Madawaska | 45 30.0 | 77 59.0 | 1906-7 | | | 9 05.2 " |
| Cobourg | 43 56.0 | 78 10.0 | 1843 | | | |
| Peterborough | 44 18.0 | 78 18.0 | 1906-7 | | | 8 16.1 " |
| Kinnmount | 44 48.0 | 78 39.0 | 1906-7 | | | 8 22.7 " |
| Mattawa | 46 19.7 | 78 41.0 | 1907 | July 23, 24. | | 8 44.3 |
| Little river | 46 15.4 | 78 44.0 | 1843 | | | |
| " | " | " | " | | | |
| Joe lake | 45 35.2 | 78 46.5 | 1907 | Aug. 6, 7. | | 7 30.6 |
| Niagara village | 43 15.0 | 79 04.0 | 1843 | | | |
| Niagara Falls | 43 04.0 | 79 05.0 | 1841 | | | |
| " | " | " | 1845 | | | |
| " | " | " | " | | | |
| South side of Trout lake | 46 18.5 | 79 13.0 | 1843 | | | |
| " | " | " | " | | | |
| Agincourt (Mag. Obsy.) | 43 47.0 | 79 16.0 | 1905 | | | 5 40.3 " |
| " | " | " | 1906-8 | | | 5 47.0 " |
| " | " | " | 1908 | July 9, 11. | | 6 2.2 " |
| " | " | " | " | " 9, 11. | | 5 59.0 " |
| Emsdale | 45 32.0 | 79 18.0 | 1906-7 | | | 7 52.2 " |

* Local disturbance.

SESSIONAL PAPER No. 25a

V.

RESULTS.

RIO.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|------------------|
| | | 76 03.1 | | | 1500 | | | C. I. |
| June 16 | | 76 16.5 | June 16 | | | 6355 | | C. Younghusband. |
| " 16 | | 76 16.3 | " 16 | | | 6361 | | " |
| April 20 | | 76 31.8 | April 20 | | | 6425 | | J. H. Lefroy. |
| " 20 | | 76 29.8 | " 20 | | | 6452 | | " |
| May 4 | | 76 35.3 | May 4 | | | 6410 | | " |
| | | | " 4 | | | 6370 | | " |
| April 19 | | 78 42.5 | | | | | | " |
| | | 75 03.6 | | | 1577 | 6118 | | White Fraser. |
| June 13 | | 76 19.8 | June 13 | | | 6320 | | C. Younghusband. |
| " 13 | | 76 18.0 | " 13 | | | 6324 | | " |
| August | | 76 42.9 | | | | | | K. Friesack. |
| | | 75 41.2 | | | 1505 | 6086 | | White-Fraser. |
| Nov. 2 | | 75 41.9 | | | 1516 | | | C. A. French. |
| | | | Nov. 23, 27 | | 1516 | | | " |
| | | 74 57.8 | | | 1613 | 6219 | | White-Fraser. |
| | | 73 27.3 | | | 1708 | 5998 | | " |
| Nov. 11 | | 77 18.8 | Nov. 11 | | | 6816 | | J. H. Lefroy. |
| " 11 | | 77 19.1 | " 11 | | | 6990 | | " |
| April 18 | | 77 18.1 | April 18 | | | 6921 | | " |
| | | | " 18 | | | 6967 | | " |
| June 10 | | 77 14.2 | June 10 | | | 6965 | | C. Younghusband. |
| " 10 | | 77 14.7 | " 10 | | | 6969 | | " |
| | | | " 11 | | | 6672 | | " |
| | | | " 11 | | | 6652 | | " |
| | | 74 37.3 | | | | | | White-Fraser. |
| | | 74 57.3 | | | 1621 | | | C. I. |
| | | | June 11 | | | 7137 | | C. Younghusband. |
| | | | " 11 | | | 7125 | | " |
| | | 75 46.7 | | | 1513 | | | C. I. |
| | | 74 54.6 | | | 1608 | 6173 | | White Fraser. |
| | | 76 11.2 | | | 1476 | 6182 | | " |
| April 17 | | 77 01.0 | | | | | | J. H. Lefroy. |
| | | 76 23.5 | | | 1461 | | | C. I. |
| | | 75 53.9 | | | 1501 | 6197 | | White-Fraser. |
| | | 75 54.0 | | | 1503 | | | C. I. |
| April 16 | | 75 27.2 | | | | | | Corporal Henry. |
| | | 74 42.9 | | | 1647 | | | C. I. |
| | | 75 18.2 | | | 1558 | | | C. I. |
| | | 76 41.2 | | | 1429 | 6205 | | White-Fraser. |
| May 12 | | 77 28.5 | May 12 | | | 6448 | | J. H. Lefroy. |
| | | | " 12 | | | 6406 | | " |
| | | 75 56.0 | | | 1525 | 6281 | | White-Fraser. |
| Mar. 11 | | 74 45.6 | Mar. 11 | | | 6387 | | J. H. Lefroy. |
| Sept. | | 74 54.7 | | | | | | J. M. Nicollet. |
| Oct. 18 | | 74 46.8 | Oct. 18 | | | 6342 | | J. H. Lefroy. |
| | | | " 18 | | | 6345 | | " |
| May 13 | | 77 21.7 | May 13 | | | 6430 | | " |
| | | | " 13 | | | 6437 | | " |
| | | 74 33.8 | | | 1643 | | | Observatory. |
| | | 74 35.6 | | | 1638 | | | C. I. |
| July 9 | | 74 32.1 | July 10, 11 | | | 1637 | | C. A. French. |
| | | | " 10, 11 | | | 1637 | | Observatory. |
| | | 75 48.7 | | | 1520 | | | C. I. |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC
ONTA

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|-------------------------------|-----------|------------|-------|-------------------|------------------------|--------------|
| Toronto, Magnetic Observatory | 43 39.4 | 79 23.3 | 1841 | 12 months.. | | 1 14.3W |
| " | " | " | 1842 | " | | 1 19.1 " |
| " | " | " | 1843 | " | | " |
| " | " | " | 1844 | " | | " |
| " | 3 | " | 1845 | 12 months.. | | 1 29.1 " |
| " | " | " | 1846 | " | | 1 30.8 " |
| " | " | " | 1847 | " | | 1 33.2 " |
| " | " | " | 1848 | " | | 1 35.4 " |
| " | " | " | 1849 | " | | 1 36.9 " |
| " | " | " | 1850 | " | | 1 38.6 " |
| " | " | " | 1851 | " | | 1 40.9 " |
| " | " | " | 1852 | " | | " |
| " | " | " | 1853 | July & Aug. | Cor. for year. | 1 46.1 " |
| " | " | " | 1854 | Feb. to June | | 1 48.0 " |
| " | " | " | 1855 | Aug. to Dec. | | 1 52.3 " |
| " | " | " | 1856 | 12 months.. | | 1 56.3 " |
| " | " | " | 1857 | " | | 2 00.5 " |
| " | " | " | 1858 | " | | 2 04.5 " |
| " | " | " | 1859 | " | | 2 07.4 " |
| " | " | " | 1860 | " | | 2 10.6 " |
| " | " | " | 1861 | " | | 2 14.4 " |
| " | " | " | 1862 | " | | 2 15.7 " |
| " | " | " | 1863 | " | | 2 19.1 " |
| " | " | " | 1864 | " | | 2 21.9 " |
| " | " | " | 1865 | " | | 2 24.8 " |
| " | " | " | 1866 | " | | 2 27.6 " |
| " | " | " | 1867 | " | | 2 29.8 " |
| " | " | " | 1868 | " | | 2 33.2 " |
| " | " | " | 1869 | " | | 2 37.1 " |
| " | " | " | 1870 | " | | 2 41.9 " |
| " | " | " | 1871 | " | | 2 47.9 " |
| " | " | " | 1872 | " | | 2 53.3 " |
| " | " | " | 1873 | " | | 2 56.9 " |
| " | " | " | 1874 | " | | 3 01.5 " |
| " | " | " | 1875 | " | | 3 06.4 " |
| " | " | " | 1876 | " | | 3 12.5 " |
| " | " | " | 1877 | " | | 3 22.6 " |
| " | " | " | 1878 | " | | 3 31.3 " |
| " | " | " | 1879 | " | | 3 36.0 " |
| " | " | " | 1880 | " | | 3 40.0 " |
| " | " | " | 1881 | " | | 3 46.6 " |
| " | " | " | 1882 | " | | 3 50.5 " |
| " | " | " | 1883 | " | | 3 54.3 " |
| " | " | " | 1884 | " | | 3 57.7 " |
| " | " | " | 1885 | " | | 3 59.8 " |
| " | " | " | 1886 | " | | 4 02.1 " |
| " | " | " | 1887 | " | | 4 04.8 " |
| " | " | " | 1888 | " | | 4 08.3 " |
| " | " | " | 1889 | " | | 4 12.0 " |
| " | " | " | 1890 | " | | 4 18.2 " |
| " | " | " | 1891 | " | | 4 23.3 " |
| " | " | " | 1892 | " | | 4 29.2 " |
| " | " | " | 1893 | " | | 4 36.4 " |
| " | " | " | 1894 | " | | 4 42.2 " |
| " | " | " | 1895 | " | | 4 44.7 " |
| " | " | " | 1896 | " | | 4 48.9 " |
| " | " | " | 1897 | " | | 4 52.8 " |
| " | " | " | 1898 | *6 " | | 4 55.0 " |

* Observatory moved to Agincourt in September 1898. The mean is interpolated from 6 months.

** For January-July, October-December; 9 months.

SESSIONAL PAPER No. 25a

V—*Con.*RESULTS—*Con.*RIO—*Con.*

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature. | Observer. |
|----------------|------------------|------|----------------|------------------|--------------|---------------|--------------|-----------|
| | | o | | | | | | |
| 12 months. | | 75 | 16 6 | | | | | |
| " | | | 16 4 | | | | | |
| " | | | 14 7 | | | | | |
| " | | | 14 8 | | | | | |
| " | | | 15 5 | 12 months. | | 64284 | | |
| " | | | 15 1 | " | | 64153 | | |
| " | | | 15 3 | " | | 64094 | | |
| " | | | 18 3 | " | | 64234 | | |
| " | | | 18 8 | " | | 64331 | | |
| " | | | 20 0 | " | | 64323 | | |
| " | | | 20 4 | " | | 64311 | | |
| " | | | 20 5 | " | | 64054 | | |
| 10 months | | | 22 2 | | | | | |
| 12 | | | 23 0 | | | | | |
| " | | | 23 5 | Sept. to Dec. | | 64276 | | |
| " | | | 24 1 | 12 months. | | 64115 | | |
| " | | | 24 3 | " | | 63830 | | |
| " | | | 24 4 | " | | 63871 | | |
| " | | | 25 0 | " | | 63745 | | |
| " | | | 24 6 | " | | 63680 | | |
| " | | | 23 8 | " | | 63709 | | |
| " | | | 23 2 | " | | 63695 | | |
| " | | | 21 5 | " | | 63642 | | |
| " | | | 20 9 | " | | 63680 | | |
| " | | | 21 0 | " | | 63675 | | |
| " | | | 19 2 | " | | 63550 | | |
| " | | | 18 8 | " | | 63610 | | |
| " | | | 20 1 | " | | 63706 | | |
| " | | | 16 7 | " | | 63625 | | |
| " | | | 16 3 | " | | 63451 | | |
| " | | | 16 8 | " | | 63520 | | |
| " | | | 15 5 | | | | | |
| " | | | 16 2 | | | | | |
| " | | | 13 9 | | | | | |
| " | | | 14 0 | | | | | |
| " | | | 13 3 | | | | | |
| " | | | 6 6 | | | | | |
| " | | | 2 4 | | | | | |
| " | | | 0 5 | | | | | |
| " | | 74 | 57 3 | | | | | |
| " | | | 59 2 | | | | | |
| " | | | 55 2 | | | | | |
| " | | | 54 1 | | | | | |
| " | | | 53 2 | | | | | |
| " | | | 51 6 | | | | | |
| " | | | 49 0 | | | | | |
| " | | | 48 0 | | | | | |
| " | | | 46 5 | | | | | |
| " | | | 44 7 | | | | | |
| " | | | 42 2 | | | | | |
| " | | | 37 5 | | | | | |
| " | | | 37 0 | | | | | |
| " | | | 35 7 | | | | | |
| " | | | 34 2 | | | | | |
| " | | | 34 2 | | | | | |
| " | | | 34 7 | | | | | |
| " | | | 36 1 | | | | | |
| " | | | 37 0 | | | | | |

**g

observations for the year.

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

ONTA

C. I.—Carnegie Institution.

L. S.—Lake Survey.

C. S.—Coast Survey.

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---|-----------|------------|--------|-----------------------------------|------------------|--------------|
| | ° ' " | ° ' " | | | | ° ' " |
| Toronto, Agincourt. | 43 47 | 79 16 | 1899 | 12 months. | | 5 26.5 W. |
| " " | " " | " " | 1900 | " | | 5 27.8 " |
| " " | " " | " " | 1901 | " | | 5 29.4 " |
| " " | " " | " " | 1902 | " | | 5 31.7 " |
| " " | " " | " " | 1903 | " | | 5 33.7 " |
| " " | " " | " " | 1904 | 10 " | | 5 36.4 " |
| " " | " " | " " | 1905 | 12 " | | 5 42.2 " |
| " " | " " | " " | 1906 | " | | 5 45.6 " |
| " " | " " | " " | 1907 | " | | 5 50.6 " |
| North Bay. | 46 18.3 | 79 24.7 | 1907 | July, 18, 19, 20 | | 08 55.6 " |
| " | 46 19.0 | 79 26.0 | 1906-8 | | | 8 44.2 " |
| Barrie. | 44 21.0 | 79 41.0 | 1843 | | | |
| New Liskeard. | 47 31.0 | 79 42.0 | 1906-8 | | | 8 50.0 " |
| Timagami sta. | 47 04.0 | 79 47.0 | 1906-8 | | | 11 54.4 " |
| Lake Nipissing | 46 11.0 | 79 48.0 | 1843 | | | |
| Hamilton, in yard of Farmers inn. | 43 16.0 | 79 50.0 | 1842 | | | |
| " " " " | " " | " " | 1845 | | | |
| Englehart | 47 50.0 | 79 52.0 | 1906-8 | | | 9 05.8 " |
| Penetanguishene. | 44 47.0 | 79 55.0 | 1906-7 | | | 6 58.9 " |
| " | " " | 79 58.0 | 1843 | | | |
| " | " " | " " | 1825 | | | |
| " | " " | " " | 1844 | | | |
| " | " " | " " | " | | | |
| Timagami inn. | 46 58.0 | 80 02.0 | 1906-8 | | | 11 26.8 " |
| Rose point. | 45 19.1 | 80 02.3 | 1907 | July 31, Aug. 1, 2, 3, 4. | | 6 49.1 |
| Twin lake. | 48 16.0 | 80 17.0 | 1906-8 | | | 7 47.5 " |
| Simcoe. | 42 51.0 | 80 18.0 | 1906-8 | | | 4 39.7 " |
| * Ricollet falls. | 45 57.0 | 80 30.0 | 1843 | | | |
| Berlin. | 43 27.0 | 80 31.0 | 1906-8 | | | 5 27.9 " |
| Owen Sound. | 44 35.0 | 80 57.0 | 1906-7 | | | 5 45.8 " |
| Sudbury. | 46 30.0 | 81 09.0 | 1906-7 | | | 6 26.8 " |
| " | 46 29.0 | 81 00.0 | 1907 | July 15, 16, 17. | | 6 54.9 " |
| Small island, Lake Huron. | 45 55.5 | 81 02.0 | 1843 | | | |
| " " " " | " " | " " | " | | | |
| Hyde Park Je. | 42 59.0 | 81 19.0 | 1906-8 | | | 3 26.8 " |
| Stokes bay. | 44 59.0 | 81 22.0 | 1905-8 | | | 6 14.8 " |
| Southampton. | 44 30.0 | 81 23.0 | 1905-8 | | | 6 04.5 " |
| Kincardine. | 44 11.0 | 81 38.0 | 1905-8 | | | 5 12.4 " |
| Frazer bay, Lake Huron. | 46 00.0 | 81 40.0 | 1843 | | | |
| Goderich, in garden foot of hill | 43 45.0 | 81 41.0 | 1845 | | | |
| " " " " | " " | " " | " | | | |
| " " " " | " " | " " | " | | | |
| " " " " | 43 46.0 | 81 42.0 | 1906-7 | | | 4 15.5 " |
| " " " " | 43 44.0 | 81 43.0 | 1863 | | | |
| Cove island. | 45 20.0 | 81 43.0 | 1890-7 | | | 3 58.6 " |
| " | " " | 81 44.0 | 1905-7 | | | 7 02.1 " |
| Goderich. | 43 44.0 | 81 44.0 | 1905-8 | | | 4 20.7 " |
| Cape Ipperwash, Lake Huron. | 43 13.0 | 82 00.0 | 1860 | | | |
| Kettle point. | 43 13.0 | 82 01.0 | 1905-8 | | | 3 43.6 " |
| Fort La Cloche, Lake Huron. | 46 07.0 | 82 03.0 | 1843 | May 18. | 8 33a | 2 10.0 " |
| " " " " | " " | " " | 1844 | | | |

* Local disturbance.

SESSIONAL PAPER No. 25a

V—*Con.*RESULTS—*Con.*RIO—*Con.*

| Month and day. | Hour and minute | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|-----------------|---------|----------------|------------------|--------------|---------------|-------------|---------------|
| 12 months. | | 74 35.9 | | | | | | |
| " | | 32.5 | | | | | | |
| " | | 32.1 | | | | | | |
| " | | 32.0 | | | | | | |
| " | | 32.6 | | | | | | |
| " | | 33.2 | | | | | | |
| " | | | | | | | | |
| " | | | | | | | | |
| " | | | | | | | | |
| " | | 76 35.7 | | | 1433 | 6182 | | White-Fraser. |
| " | | 76 37.4 | | | 1442 | | | C. I. |
| Jan. 24. | | 75 49.9 | | | | | | J. H. Lefroy. |
| " | | 77 34.7 | | | 1348 | | | C. I. |
| " | | 76 05.9 | | | 1521 | | | C. I. |
| May 14. | p.m. | 77 09.5 | May 14. | | | 6391 | | J. H. Lefroy. |
| Dec. 29. | | 74 56.7 | Dec. 29. | | | 6374 | | " |
| " 31. | | 74 54.1 | | | | | | J. H. Lefroy. |
| " | | 77 49.6 | | | 1320 | | | C. I. |
| " | | 75 27.9 | | | 1556 | | | C. I. |
| Jan. 26. | | 76 04.2 | | | | | | J. H. Lefroy. |
| April 18. | | 76 16.0 | | | | | | Franklin. |
| Nov. 11. | | 76 19.2 | Nov. 11. | | | 6491 | | J. H. Lefroy. |
| " 11. | | 76 21.0 | " 15. | | | 6483 | | " |
| " | | | " 15. | | | 6483 | | " |
| " | | | " 15. | | | 6506 | | " |
| " | | 76 47.4 | | | 1428 | | | C. I. |
| " | | 75 36.1 | | | 1525 | 6588 | | White-Fraser. |
| " | | 77 39.4 | | | 1365 | | | C. I. |
| " | | 74 04.6 | | | 1701 | | | C. I. |
| May 15. | 2 00p | 76 45.4 | May 15. | | | 6531 | | J. H. Lefroy. |
| " | | | " 15. | | | 6406 | | " |
| " | | 74 23.3 | | | 1665 | | | C. I. |
| " | | 75 10.7 | | | 1590 | | | C. I. |
| " | | 76 22.0 | | | 1477 | 6254 | | C. I. |
| " | | 76 35.2 | | | 1451 | | | White-Fraser. |
| May 16. | | 76 31.3 | May 16. | | | 6422 | | J. H. Lefroy. |
| " | | | " 16. | | | 6394 | | " |
| " | | | " 16. | | | 6448 | | " |
| " | | 73 56.6 | | | 1704 | | | C. I. |
| " | | 75 32.0 | | | 1538 | | | L. S. |
| " | | 75 00.0 | | | 1584 | | | L. S. |
| " | | 74 36.0 | | | 1641 | | | L. S. |
| May 17. | 2 00p | 77 05.6 | May 17. | 2 00p | | 6412 | | J. H. Lefroy. |
| " | | | " 17. | | | 6411 | | " |
| Oct. 28. | | 75 04.4 | Oct. 28. | | | 6380 | | " |
| " | | | " 28. | | | 6374 | | " |
| Oct. 28. | | 75 05.3 | " 28. | | | 6376 | | " |
| " | | | " 28. | | | 6383 | | " |
| " | | 74 26.5 | | | 1660 | | | C. I. |
| July 19. | | 75 02.0 | | | | 6383 | | W. P. Smith |
| " | | 76 32.0 | | | 1506 | | | L. S. |
| " | | 75 41.0 | | | 1553 | | | L. S. |
| " | | 74 29.0 | | | 1645 | | | L. S. |
| May 8. | | 74 46.0 | May 28. | | | 6427 | | W. P. Smith. |
| " | | 74 03.0 | " | | 1686 | | | L. S. |
| Nov. 8. | | 76 50.2 | | | | | | J. H. Lefroy. |
| " | | | | | | | | " |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

ONTA

C. I.—Carnegie Institution.

L. S.—Lake Survey.

C. S.—Coast "

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|-----------------------------------|-----------|------------|--------|-----------------|------------------|--------------|
| Biscotasing | 47 18.0 | 82 08.0 | 1906-7 | | | 3 07.2 " |
| Chatham | 42 24.0 | 82 10.0 | 1906-8 | | | 2 13.8 " |
| Providence bay | 45 40.0 | 82 17.0 | 1905-7 | | | 4 26.4 " |
| Sarnia, garden near the ferry.. | 45 58.0 | 82 22.0 | 1845 | | | |
| " " | " " | " " | " " | | | |
| " " | 45 58.0 | 82 22.0 | 1845 | | | |
| Snake island, Lake Huron | 46 10.0 | 82 40.0 | 1843 | | | |
| " " | " " | " " | " " | | | |
| Algoma | 46 11.0 | 82 50.0 | 1906-8 | | | 4 35.4 W. |
| Great Duck island | 45 38.0 | 82 56.0 | 1905-7 | | | 2 22.8 |
| Amherstburg | 42 06.0 | 83 03.0 | 1845 | | | |
| " " | " " | " " | " " | | | |
| Missisagi straits | 45 54.0 | 83 14.0 | 1905-7 | | | 4 06.4 " |
| *Cockburn island | 45 52.0 | 83 21.0 | 1905-7 | | | 2 11.3 E. |
| Chapleau | 47 50.0 | 83 27.0 | 1906-8 | | | 4 04.0 W. |
| " " | 47 49.6 | 83 27.0 | 1907 | July 11, 12, 13 | | 3 47.0 |
| Thessalon point, Lake Huron .. | 46 17.0 | 83 33.0 | 1843 | May 19 | 3-26p | 0 11.4 " |
| " " | " " | " " | " " | | | |
| Missinaibi | 48 20.0 | 84 07.0 | 1906-7 | | | 5 39.1 " |
| Sault Ste. Marie | 46 30.9 | 84 21.5 | 1844 | Nov. 4 | 9-56a | 1 14.1 E. |
| " " | " " | " " | " " | 4 | 10-05a | 0 51.1 " |
| " " | " " | " " | " " | 4 | 11-05a | 1 08.2 " |
| " " | " " | " " | 1845 | | | |
| Pointe aux Pins, Lake Superior | 46 29.9 | 84 29.0 | 1843 | | | |
| " " | " " | " " | " " | | | |
| " " | " " | " " | " " | | | |
| Sinclair harbour | 47 22.0 | 84 42.0 | 1906-6 | | | 2 41.4 W. |
| Parisian island | 46 39.0 | 84 42.0 | 1906-6 | | | 2 37.6 " |
| Gros Cap | 46 32.0 | 84 43.0 | 1841 | | | |
| Pointe aux Crêpes, Lake Superi | 46 58.0 | 84 44.0 | 1843 | May 21 | 5-08p | 3 02.8 E. |
| Mamaine point | 47 02.0 | 84 47.0 | 1906-6 | | | 0 34.7 " |
| Michipicoten, Lake Superior.. | 47 56.0 | 84 50.6 | 1880 | July 21, Sep. 9 | | 1 20.5 W. |
| " " | 47 56.2 | 84 54.0 | 1843 | May 23 | 9-55a | 0 20.3 E. |
| " " | " " | " " | " " | | | |
| " " | " " | " " | 1844 | | | |
| " " | " " | " " | " " | | | |
| " " | " " | " " | " " | | | |
| " " | " " | " " | 1845 | | | |
| Gargantua I. | 47 34.0 | 84 58.0 | 1906-7 | | | 2 26.3 W. |
| *Cape Gargantua, L. Superior | 47 36.9 | 85 05.0 | 1843 | May 21 | 2-15p | 0 38.0 E. |
| " " | " " | " " | " " | | | |
| " " | " " | " " | " " | | | |
| White river | 48 36.0 | 85 18.0 | 1906-7 | | | 3 00.6 W. |
| Michipicoten I. | 47 42.0 | 85 46.0 | 1906-7 | | | 1 49.2 E. |
| Caribou I. No 1. | 47 20.0 | 85 50.0 | 1906-7 | | | 1 16.6 W. |
| Otter island | 48 06.0 | 86 03.0 | 1906-7 | | | 4 07.3 " |
| *S. E. of Otter I., Lake Superior | 48 07.0 | 86 07.0 | 1843 | | | |
| " " | " " | " " | " " | | | |
| Tip-Top | 48 15.0 | 86 08.0 | 1871 | | | |
| Oiseaux bay | 48 22.0 | 86 10.0 | 1906-7 | | | 1 41.4 " |
| Rivière Blanche, Lake Superior | 48 31.7 | 86 14.0 | 1844 | Oct. 21 | 3-51p | 2 15.2 E. |
| " " | " " | " " | " " | | | |
| " " | " " | " " | " " | | | |
| Pic, Lake Superior | 48 35.3 | 86 15.0 | 1843 | | | |
| " " | " " | " " | " " | | | |
| " " | " " | " " | 1844 | Oct. 18 | 10-38a | 5 13.3 E. |
| " " | " " | " " | " " | 18 | 11-06a | 5 52.5 " |
| " " | " " | " " | " " | | | |

* Local disturbance.

SESSIONAL PAPER No. 25a

V—Con.

RESULTS—Con.

RIO—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|------------------|
| | | 77 09.4 | | | 1384 | | | C. I. |
| | | 73 33.4 | | | 1749 | | | C. I. |
| | | 76 00.0 | | | 1513 | | | L. S. |
| Oct. 25. | | 74 18.6 | | | | 6366 | | J. H. Lefroy. |
| | | | | | | 6370 | | " |
| Oct. 27. | | 74 12.9 | | | | 6370 | | " |
| | | | | | | 6362 | | " |
| May 18. | | 77 05.5 | May 18. | | | 6383 | | " |
| | | | " 18. | | | 6393 | | " |
| | | 76 24.0 | | | 1467 | | | C. I. |
| | | 76 24.0 | | | 1461 | | | L. S. |
| Oct. 22. | | 73 32.7 | Oct. 22. | | | 6347 | | J. H. Lefroy. |
| " 22. | | 73 27.2 | " 22. | | | 6342 | | " |
| | | 76 40.0 | | | 1421 | | | L. S. |
| | | 77 00.0 | | | 1421 | | | L. S. |
| | | 77 50.6 | | | 1329 | | | C. I. |
| | | 77 54.1 | | | 1321 | 6304 | | White-Fraser. |
| May 19. | | 76 59.3 | May 19. | | | 6484 | | J. H. Lefroy. |
| " 19. | | 77 04.8 | " 19. | | | 6418 | | " |
| | | 77 51.6 | | | 1330 | | | C. I. |
| Nov. 4. | | 77 46.2 | Nov. 4. | | | 6365 | | J. H. Lefroy. |
| " 4. | | 77 45.6 | " 4. | | | 6369 | | " |
| | | | " 4. | | | 6386 | | " |
| May | | 77 19.5 | | | | | | Dr. J. Rae. |
| " 20. | | 77 13.4 | May 20. | | | 6510 | | J. H. Lefroy. |
| " 20. | | 77 12.1 | " 20. | | | 6462 | | " |
| | | | " 20. | | | 6481 | | " |
| | | 77 26.0 | | | 1411 | | | L. S. |
| | | 76 44.0 | | | 1478 | | | L. S. |
| Aug. | | 77 05.3 | | | | | | F. Loomis. |
| May 21. | | 77 11.5 | May 21. | | | 6436 | | J. H. Lefroy. |
| | | 77 18.0 | | | 1444 | | | L. S. |
| | | | | | | | | S. W. Very. |
| May 23. | | 78 06.3 | May 23. | | | 6460 | | J. H. Lefroy. |
| " 23. | | 78 04.4 | " 23. | | | 6496 | | " |
| Oct. 30. | | 78 08.1 | Oct. 30. | | | 6435 | | " |
| " 30. | | 78 08.5 | " 30. | | | 6462 | | " |
| | | | " 30. | | | 6417 | | " |
| | | 75 05.2 | | | | | | Dr. J. Rae. |
| | | 77 54.0 | | | 1374 | | | L. S. |
| May 21. | | 77 56.1 | May 21. | | | 7019 | | J. H. Lefroy. |
| | | | " 21. | | | 7050 | | " |
| | | | " 21. | | | 7042 | | " |
| | | 78 15.9 | | | 1291 | | | C. I. |
| | | 77 36.0 | | | 1379 | | | L. S. |
| | | 77 02.0 | | | 1451 | | | L. S. |
| | | 78 42.0 | | | 1253 | | | L. S. |
| May 24. | 1-30p | 79 43.6 | May 24. | | | 6226 | | J. H. Lefroy. |
| " 24. | | 79 32.8 | " 24. | | | 6330 | | " |
| Aug. 26. | | 78 56.0 | Aug. 26. | | | 6358 | | C. B. Coomstock. |
| | | 78 04.0 | | | 1319 | | | L. S. |
| Oct. 21. | 2-00p | 78 33.7 | Oct. 21. | | | 6509 | | J. H. Lefroy. |
| " 21. | | 78 32.5 | " 21. | | | 6524 | | " |
| | | | " 21. | | | 6494 | | " |
| May 25. | a.m. | 78 45.8 | May 25. | | | 6412 | | " |
| " 25. | a.m. | 78 40.8 | " 25. | | | 6460 | | " |
| Oct. 17. | a.m. | 78 32.8 | Oct. 17. | | | 6359 | | " |
| " 17. | a.m. | 78 29.9 | " 17. | | | 6387 | | " |
| | | | " 17. | | | 6349 | | " |

6-10 EDWARD VII., A. 1910

TABLE
MAGNETICC. I.—Carnegie Institution.
L. S.—Lake Survey.
C. S.—Coast "

ONTA

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---------------------------------|-----------|------------|--------|----------------|------------------|--------------|
| Pic, Lake Superior | 48 35.3 | 86 15.0 | 1845 | | | |
| Peninsula harbor | 48 42.0 | 86 20.0 | 1906-7 | | | 4 53.7W |
| " | 48 44.0 | 86 28.0 | 1824 | | | |
| *Black Rock | 48 41.0 | 86 30.0 | 1906-7 | | | 19 26.4W |
| Pic island | 48 42.0 | 86 34.0 | 1906-7 | | | 2 45.8 " |
| Sunday harbor | 48 37.0 | 86 59.0 | 1906-7 | | | 1 21.0 " |
| Schreiber | 48 49.0 | 87 18.0 | 1906-7 | | | 0 22.4 " |
| *Battle island, Lake Superior | 48 45.0 | 87 33.0 | 1843 | | | |
| " | 48 45.0 | 87 33.0 | 1843 | | | |
| " | 48 45.0 | 87 33.0 | 1843 | | | |
| " | 48 45.0 | 87 33.0 | 1906-7 | | | 1 57.6W |
| Simpson island, L. Superior | 48 49.0 | 87 45.0 | 1843 | May 27 | 6-30a | 5 44.8 E |
| " | 48 49.0 | 87 45.0 | 1843 | | | |
| Isle St. Ignace | 48 46.0 | 87 48.0 | 1906-7 | | | 4 58.1 " |
| Spar Point island | 48 38.0 | 88 06.0 | 1906-7 | | | 2 00.2 " |
| Lamb island | 48 36.0 | 88 08.0 | 1906-7 | | | 6 12.0 " |
| *Porcupine island | 48 38.0 | 88 09.0 | 1906-7 | | | 21 30.1W |
| Nipigon | 49 01.0 | 88 16.0 | 1906-7 | | | 1 17.5 E |
| Roches de Bout ids. | 48 31.0 | 88 21.0 | 1906-7 | | | 0 29.4W |
| Big Edward island | 48 22.0 | 88 38.0 | 1906-8 | | | 3 28.4 E |
| Porphyry point | 48 21.0 | 88 38.0 | 1906-8 | | | 3 16.2 " |
| Five miles east of Thunder cape | 48 20.0 | 88 52.0 | 1843 | | | |
| " | 48 20.0 | 88 52.0 | 1843 | | | |
| Thunder harbor | 48 19.0 | 88 53.0 | 1906-8 | | | 2 14.0 E |
| Port Arthur | 48 26.0 | 89 12.6 | 1884 | | | |
| Fort William | 48 23.5 | 89 13.5 | 1843 | May 29 | 5-32p | 6 14.3 E |
| " | 48 23.5 | 89 13.5 | 1843 | " 30 | 4-12p | 6 41.9 " |
| " | 48 23.5 | 89 13.5 | 1843 | " 30 | 4-17p | 6 56.6 " |
| " | 48 23.5 | 89 13.5 | 1843 | " 31 | 9-11a | 6 46.1 " |
| " | 48 23.5 | 89 13.5 | 1824 | | | 9 05.0 " |
| " | 48 23.5 | 89 13.5 | 1825 | May 12 | | 7 17.5 " |
| " | 48 23.5 | 89 13.5 | 1844 | Oct. 11 | | 5 01.4 " |
| " | 48 23.5 | 89 13.5 | 1844 | | | |
| " | 48 23.5 | 89 13.5 | 1844 | | | |
| Fort William school | 48 24.0 | 89 14.0 | 1902-8 | | | 3 49.9E |
| Fort William mission | 48 24.0 | 89 14.0 | 1902-8 | | | 3 32.9 " |
| Fort William | 48 24.0 | 89 14.0 | 1906-7 | | | 3 37.2 " |
| Sturgeon bay | 48 11.0 | 89 18.0 | 1906-8 | | | 2 18.1 " |
| *Victoria island | 48 05.0 | 89 21.0 | 1906-8 | | | 0 31.3 " |
| Dog portage | 48 39.0 | 89 30.0 | 1843 | | | |
| " | 48 39.0 | 89 30.0 | 1843 | | | |
| " | 48 39.0 | 89 30.0 | 1844 | | | |
| " | 48 39.0 | 89 30.0 | 1844 | | | |
| " | 48 39.0 | 89 30.0 | 1844 | | | |
| Pigeon river | 48 00.0 | 89 34.0 | 1906-8 | | | 2 44.8 E |
| *Portage Ecarté | 48 25.0 | 89 44.0 | 1843 | | | |
| " | 48 25.0 | 89 44.0 | 1843 | | | |
| Prairie portage | 48 57.5 | 90 01.5 | 1843 | | | |
| " | 48 57.5 | 90 01.5 | 1843 | | | |
| " | 48 57.5 | 90 01.5 | 1844 | | | |
| " | 48 57.5 | 90 01.5 | 1844 | | | |
| " | 48 57.5 | 90 01.5 | 1844 | | | |
| S. W. of Savanne portage | 48 53.0 | 90 03.3 | 1825 | May 21 | | 9 23.9 E |
| " | " | " | 1843 | June 6 | 7-52a | 8 06.3 " |
| " | " | " | 1844 | Oct. 6 | 7-12p | 7 23.1 " |

* Local disturbance.

SESSIONAL PAPER No. 25a

V—Con.

RESULTS—Con.

RIO—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|---------------|
| May .. | | 78 34.0 | | | | | | Dr. J. Rae. |
| | | 77 47.0 | | | 1419 | | | L. S. |
| | | 78 34.0 | | | | | | Bayfield. |
| | | 81 50.0 | | | 1016 | | | L. S. |
| | | 78 08.0 | | | 1320 | | | L. S. |
| | | 78 18.0 | | | 1298 | | | L. S. |
| | | 78 21.8 | | | 1271 | | | C. I. |
| May 26 .. | | 76 24.0 | May 26 .. | | | 6294 | | J. H. Lefroy. |
| | | | " 26 .. | | | 6300 | | " |
| | | | " 26 .. | | | 6291 | | " |
| | | 79 04.0 | | | 1234 | | | L. S. |
| May 27 .. | 8-00a | 78 53.6 | May 27 .. | | | 6468 | | J. H. Lefroy. |
| " 27 .. | | 78 46.2 | " 27 .. | | | 6457 | | " |
| | | 78 10.0 | | | 1298 | | | L. S. |
| | | 78 26.0 | | | 1021 | | | L. S. |
| | | 79 20.0 | | | 1164 | | | L. S. |
| | | 68 48.0 | | | 1983 | | | L. S. |
| | | 78 28.6 | | | 1274 | | | C. I. |
| | | 78 55.0 | | | 1251 | | | L. S. |
| | | 78 21.0 | | | 1294 | | | L. S. |
| | | 78 06.0 | | | 1315 | | | L. S. |
| May 28 .. | | 78 23.2 | May 28 .. | | | 6587 | | J. H. Lefroy. |
| " 28 .. | | 78 30.0 | " 28 .. | | | 6480 | | " |
| | | 78 00.0 | | | 1305 | | | L. S. |
| July 14 .. | 2-40 to 3-20p | 78 09.0 | July 14 .. | 3-45 to 5-30p | | 6402 | | E. Deville. |
| May 29 .. | | 78 09.7 | May 29 .. | | | 6528 | | J. H. Lefroy. |
| " 29 .. | | 78 10.2 | " 29 .. | | | 6509 | | " |
| | | | " 29 .. | | | 6500 | | " |
| | | | " 31 .. | | | 6452 | | " |
| | | | | | | 6457 | | " |
| May 11 .. | | 78 20.0 | | | | | | Bayfield. |
| Oct. 11 .. | | 78 07.5 | Oct. 11 .. | | | 6428 | | Franklin. |
| " 11 .. | | 77 55.5 | " 11 .. | | | 6423 | | J. H. Lefroy. |
| " 11 .. | | 77 55.5 | " 11 .. | | | 6387 | | " |
| | | 78 11.0 | | | | | | Dr. J. Rae. |
| | | 77 54.6 | | | 1332 | | | C. S. |
| | | 77 54.9 | | | 1331 | | | C. S. |
| | | 77 48.0 | | | 1341 | | | C. I. |
| | | 77 29.0 | | | 1349 | | | L. S. |
| | | 77 51.0 | | | 1348 | | | L. S. |
| June 3 .. | 4-30p | 78 26.8 | June 3 .. | | | 6518 | | J. H. Lefroy. |
| " 3 .. | | 78 25.0 | " 3 .. | | | 6480 | | " |
| | | | Oct. 9 .. | | | 6507 | | " |
| | | | " 9 .. | | | 6533 | | " |
| | | | " 9 .. | | | 6547 | | " |
| | | 78 07.0 | | | 1295 | | | L. S. |
| June 2 .. | | 77 13.5 | June 2 .. | | | 6463 | | J. H. Lefroy. |
| | | | " 2 .. | | | 6442 | | " |
| June 5 .. | | 78 26.1 | " 5 .. | | | 6486 | | " |
| " 5 .. | | 78 28.2 | " 5 .. | | | 6446 | | " |
| | | | Oct. 7 .. | | | 6515 | | " |
| | | | " 7 .. | | | 6560 | | " |
| | | | " 7 .. | | | 6543 | | " |
| May 20 .. | | 78 39.1 | | | | | | Franklin. |
| Oct. 6 .. | 11-00a | 78 21.8 | Oct. 6 .. | | | 6507 | | J. H. Lefroy. |
| | | | | | | | | " |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC

ONTA

C. I.—Carnegie Institution.
L. S.—Lake Survey.
C. S.—Coast Survey.

| Place. | Latitude. | Longitude. | Year. | Month and Day. | Hour and Minute. | Declination. |
|---|-----------|------------|--------|-------------------|------------------------|--------------|
| | ° ' " | ° ' " | | | | ° ' " |
| S. W. of Savanne portage | 48 53.0 | 90 03.3 | 1844 | Oct. 6.... | 7-50a | 7 25.6 E |
| " " " " " " " " " " | " | " | 1857 | " | " | 6 53.0 " |
| Savanne..... | 48 58.0 | 90 14.0 | 1906 7 | " | " | 4 33.8 " |
| French portage | 48 35.0 | 91 08.4 | 1843 | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| End of the portage of the Two Rivers | 48 35.0 | 91 23.0 | 1843 | June 9.... | 9-50a | 10 57.6 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | 1844 | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| Ignace..... | 49 25.0 | 91 40.0 | 1906 7 | " | " | 6 14.6 " |
| E. end of Lac à la Crosse..... | 48 24.0 | 92 04.0 | 1843 | June 10.... | 7-44a | 7 52.5 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| 2nd portage, Lac à la Crosse..... | 48 14.2 | 92 25.0 | " | June 11.... | 7-41a | 10 40.3 " |
| " " " " " " " " " " | " | " | " | " | 8 13a | 10 01.0 " |
| Sturgeon lake | 48 27.5 | 92 38.0 | " | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| Farrington..... | 48 46.0 | 92 48.0 | 1906 8 | " | " | 7 39.2 " |
| S. side, Lac à la Pluie..... | 48 33.4 | 92 50.0 | 1843 | June 13.... | 9-30a | 10 53.6 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| Eagle river..... | 49 48.0 | 93 11.0 | 1906 7 | " | " | 6 39.7 " |
| Fort Frances..... | 48 36.6 | 93 26.7 | 1825 | May 28.... | " | 10 42.6 " |
| " " " " " " " " " " | " | " | 1843 | June 14.... | 6-25p | 10 33.3 " |
| " " " " " " " " " " | " | " | " | " | 6-52p | 10 36.7 " |
| " " " " " " " " " " | " | " | " | " | 6-00 | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | 1844 | Sept. 30.... | 9-26a | 8 56.7 " |
| " " " " " " " " " " | " | " | " | " | 3-17p | 8 34.1 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | 1845 | " | " | " |
| " " " " " " " " " " | " | " | 1857 | " | " | 9 31.0 " |
| Kencora..... | 49 46.0 | 94 26.0 | 1906 7 | " | " | 9 54.1 " |
| Near Rat portage, Winnipeg river | 49 46.3 | 94 29.4 | 1885 | June 22.... | 10-30a | 11 55.7 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| On N. bank of Rainy river.... | 48 41.0 | 94 31.0 | 1843 | June 16.... | 7-48a | 13 04.5 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| *Rainy river..... | 48 43.0 | 94 31.0 | 1906 8 | " | " | 9 33.8 " |
| Rat portage | 49 45.9 | 94 33.3 | 1843 | June 20.... | 10-11a | 9 38.0 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | 1844 | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | " | " | " | " | " | " |
| Winnipeg river..... | 49 53.1 | 94 34.2 | 1885 | June 25.... | 10-00a | 10 09.1 " |
| Island in Lake of the Woods... | 49 25.0 | 94 37.0 | 1843 | June 18.... | 3-14p | 12 26.0 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| " " " " " " " " " " | 49 19.0 | 94 40.0 | " | June 17.... | 7-58a | 13 42.6 " |
| " " " " " " " " " " | " | " | " | " | " | " |
| Sand lake, Winnipeg river | 50 02.5 | 94 41.9 | 1885 | June 28.... | 10-45a | 10 53.2 " |
| Settlement, mouth of White Dog river..... | 50 08.2 | 94 54.4 | 1885 | July 1.... | 5-45p | 9 41.0 " |

*Local disturbance.

SESSIONAL PAPER No. 25a

V—Con.

RESULTS—Con.

RIO—Con.

| Month and Day. | Hour and Minute. | Dip. | Month and Day. | Hour and Minute | Hor. Intens. | Total Intens. | Temperature. | Observer. |
|----------------|------------------|---------|----------------|-----------------|--------------|---------------|--------------|---------------|
| Oct. 6. | | 78 14.4 | Oct. 6. | | | .6499 | " | J. H. Lefroy. |
| | | 78 09.9 | | | 1304 | | | Palliser. |
| June 8 | | 78 20.4 | June 8 | | | .6494 | | C. I. |
| " | | 78 05.5 | " | | | .6471 | | J. H. Lefroy. |
| June 9 | | 77 49.4 | June 9 | | | .6508 | | " |
| " | | 77 53.2 | " | | | .6473 | | " |
| | | | Oct. 4 | | | .6384 | | " |
| | | | " | | | .6422 | | " |
| | | | " | | | .6407 | | " |
| | | 78 27.4 | | | 1279 | | | C. I. |
| June 10 | 10-00a | 77 51.0 | June 10 | | | .6488 | | J. H. Lefroy. |
| | | | " | | | .6474 | | " |
| June 11 | | 77 40.1 | June 11 | | | .6473 | | " |
| | | | " | | | .6453 | | " |
| June 12 | 1-00p | 77 44.8 | June 12 | | | .6503 | | " |
| | | | " | | | .6462 | | " |
| | | 77 42.4 | | | 1349 | | | C. I. |
| June 13 | | 77 47.9 | June 13 | | | .6515 | | " |
| " | | 77 28.7 | " | | | .6461 | | " |
| | | 78 07.8 | | | 1313 | | | " |
| May 28 | | 77 18.1 | June 14 | | | .6467 | | Franklin. |
| June 14 | | 77 28.0 | " | | | .6480 | | J. H. Lefroy. |
| | | 77 22.8 | " | | | .6420 | | " |
| | | | " | | | .6471 | | " |
| | | | " | | | .6475 | | " |
| | | | Sept. 29 | | | .6456 | | " |
| | | | " | | | .6487 | | " |
| | | | " | | | .6488 | | " |
| | | 77 32.0 | | | | | | Dr. J. Rae. |
| | | | | | | | | Palliser. |
| | | 77 58.9 | | | 1318 | | | C. I. |
| | 10-25a | | | 1-23 | | | | |
| June 22 | to 10-45p | 78 31.3 | June 22 | to 2-10p | | .6444 | 87 | Th. Fawcett. |
| | 8-38 | | | 9-40 | | | | |
| Oct. 19 | to 9-00a | 78 36.1 | Oct. 19 | to 10-11a | | .6445 | 34 | " |
| | 9-03 | | | 10-11 | | | | |
| " | to 9-35a | 78 38.5 | " | to 10-50a | | .6403 | 37 | " |
| June 16 | 9-00a | 77 57.4 | June 16 | | | .6503 | | J. H. Lefroy. |
| " | | 78 14.9 | " | | | .6633 | | " |
| | | | " | | | .6575 | | " |
| | | 77 27.2 | | | 1376 | | | C. I. |
| June 20 | | 78 07.5 | June 20 | | | .6480 | | J. H. Lefroy. |
| " | | 78 07.1 | " | | | .6463 | | " |
| " | | 78 00.5 | " | | | | | " |
| | | | Sept. 25 | | | .6417 | | " |
| | | | " | | | .6452 | | " |
| | | | " | | | .6446 | | " |
| | 10-10 | | | 2-00 | | | | |
| June 25 | to 11-30a | 78 28.3 | June 25 | to 2-45p | | .6504 | 79 | Th. Fawcett. |
| June 18 | 1-00p | 78 16.7 | June 18 | | | .6503 | | J. H. Lefroy. |
| " | | 78 15.2 | " | | | .6413 | | " |
| June 17 | 9-20a | 78 03.7 | June 17 | | | .6516 | | " |
| " | | 78 01.7 | " | | | .6482 | | " |
| | 11-20 | | | 1-20 | | | | |
| June 28 | to 12-45a | 78 31.4 | June 28 | to 1-43p | | .6538 | 82 | Th. Fawcett. |
| | 6-17 | | | 7-02 | | | | |
| July 1. | to 7-00p | 78 28.2 | July 1. | to 8 00p | | .6518 | 72 | " |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC
HUDSON BAY AND

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|-----------------------------------|-----------|------------|-------|----------------------|------------------------|--------------|
| | ° ' " | ° ' " | | | | ° ' " |
| Eastmain | 52 14.7 | 78 29.3 | 1890 | Sept. 11 . . . | 5-25 to 5-45p | 15 01.6W |
| " | " | " | " | Oct. 2 | 4-25 to 4-41p | 14 51.5 " |
| " | " | " | " | | | |
| " | " | " | " | | | |
| Rupert House | 51 29.5 | 78 43.4 | 1890 | Aug. 13. . . . | 5-14 to 5-38p | 14 15.1 " |
| " | " | " | " | | | |
| " | " | " | " | | | |
| At sea, Hudson bay | 63 17.0 | 78 55.0 | 1846 | | | 58 15.0 " |
| " | 60 10.0 | 80 10.0 | 1846 | | | |
| " | 62 10.0 | 80 10.0 | " | | | |
| " | 52 20.0 | 80 17.0 | " | | | |
| " | 51 32.0 | 80 34.0 | " | | | 10 41.0 " |
| " | 53 24.0 | 81 06.0 | " | | | |
| " | 53 42.0 | 81 09.0 | " | | | 12 48.0 " |
| " | 60 20.0 | 81 12.0 | " | | | |
| " | 62 20.0 | 81 12.0 | " | | | |
| " | 53 57.0 | 81 30.0 | " | | | |
| " | 54 43.0 | 81 32.0 | " | | | 13 30.0 " |
| " | 56 24.0 | 81 50.0 | " | | | |
| " | 56 40.0 | 81 57.0 | " | | | |
| " | 60 26.0 | 82 0.80 | " | | | |
| " | 55 25.0 | 82 14.0 | " | | | 11 53.0 " |
| " | 55 29.0 | 82 24.0 | " | | | |
| " | 57 15.0 | 82 33.0 | " | | | 15 57.0 " |
| " | 57 04.0 | 82 37.0 | " | | | |
| " | 57 32.0 | 82 37.0 | " | | | 16 15.0 " |
| " | 57 09.0 | 82 42.0 | " | | | 17 16.0 " |
| " | 60 25.0 | 82 42.0 | " | | | |
| " | 59 11.0 | 82 45.0 | " | | | |
| " | 60 45.0 | 82 45.0 | " | | | |
| " | 61 07.0 | 82 50.0 | " | | | |
| " | 58 53.0 | 82 52.0 | " | | | 20 52.0 " |
| " | 57 15.0 | 82 53.0 | " | | | 15 57.0 " |
| On shore, Hudson bay | 51 08.0 | 80 44.0 | " | | | 10 55.0 " |
| Moose Factory | 51 15.0 | 80 56.0 | " | | | 12 40.0 " |
| " | 51 15.4 | 80 40.5 | 1880 | Aug. 14, 17, 20 | | 15 27.5 " |
| " | | | | | 4-15 | |
| " | 51 14.5 | 80 56.0 | 1890 | July 24 | to 4-48p | 15 14.7 " |
| " | " | " | " | | | |
| Fort Albany, Hudson bay | 51 22.0 | 82 38.0 | 1775 | | | |
| Fort Hope | 66 32.0 | 86 56.0 | 1846 | | | |
| " | " | " | " | | | |
| " | " | " | 1847 | | | |
| " | " | " | " | | | |

SESSIONAL PAPER No. 25a

VI.

RESULTS.

SURROUNDING TERRITORY.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. Intens. | Total Intens. | Temperature | Observer. |
|----------------|--------------------|---------|----------------|------------------|--------------|---------------|-------------|-----------------|
| Sept. 11 | 3-20 to 3-46p | 80 43.4 | | | | | | Wm. Ogilvie. |
| " 11 | 4-16 to 4-30p | 80 46.7 | | | | | | " |
| Oct. 2 | 2-28 to 2-57p | 80 47.4 | | | | | | " |
| " 2 | 3-35 to 3-56p | 80 42.6 | | | | | | " |
| Aug. 13 | 10-58 to 11-22a | 80 26.6 | | | | | | " |
| " 13 | 11-57 to 12-18a | 80 34.2 | | | | | | " |
| Oct. 5 | 3-47 to 4 09p | 80 33.8 | | | | | | " |
| | | 86 35.0 | | | | 6248 | | T. E. L. Moore. |
| | | 87 01.0 | | | | 6160 | | " |
| | | 87 01.0 | | | | 6160 | | " |
| | | 81 49.0 | | | | | | " |
| | | 80 59.0 | | | | | | " |
| | | 82 20.0 | | | | | | " |
| | | | | | | 6401 | | " |
| | | 86 07.0 | | | | | | " |
| | | 86 07.0 | | | | | | " |
| | | 83 02.0 | | | | 6358 | | " |
| | | 83 47.0 | | | | 6381 | | " |
| | | 84 10.0 | | | | | | " |
| | | 84 42.0 | | | | 6248 | | " |
| | | 85 20.0 | | | | 6257 | | " |
| | | 84 00.0 | | | | 6266 | | " |
| | | 83 48.0 | | | | 6114 | | " |
| | | 84 30.0 | | | | 6266 | | " |
| | | 84 31.0 | | | | | | " |
| | | 85 15.0 | | | | 6123 | | " |
| | | 84 36.0 | | | | | | " |
| | | 86 36.0 | | | | 6095 | | " |
| | | 86 30.0 | | | | 6280 | | " |
| | | 86 41.0 | | | | 6261 | | " |
| | | 87 00.0 | | | | 6082 | | " |
| | | 85 48.0 | | | | | | " |
| | | 84 34.0 | | | | 6238 | | " |
| | | 81 02.0 | | | | 6487 | | " |
| | | 81 30.0 | | | | 6516 | | " |
| | | | | | | | | S. W. Very. |
| July 22. . . | 10-20 to 10-48a | 80 48.5 | | | | | | Wm. Ogilvie. |
| " 23 | 11-30 to 11-57a | 80 52.0 | | | | | | " |
| November .. | | 79 20.0 | | | | | | Hutchins. |
| December .. | | 88 03.8 | | | | | | Dr. J. Rae. |
| January | | 88 14.0 | | | | | | " |
| February | | 88 17.5 | | | | | | " |
| | | 88 12.2 | | | | | | " |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

HUDSON BAY AND

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--|-----------|------------|-------|----------------|------------------|--------------|
| Repulse bay..... | 66 32.0 | 86 55.0 | 1846 | ..... | ..... | ..... |
| Near Wager river..... | 65 10.0 | 87 30.0 | " | ..... | ..... | ..... |
| Three miles N. W. of cape Lady Pelly..... | 64 30.0 | 88 00.0 | " | ..... | ..... | ..... |
| Knapp bay..... | 64 06.0 | 88 00.0 | " | ..... | ..... | ..... |
| "..... | 61 09.7 | ..... | " | ..... | ..... | ..... |
| Mouth of Albany R., Lake St. Joseph..... | 51 12.7 | 90 09.8 | 1885 | Sept. 10 ... | 3-50p | 6 09.0 E |
| " "..... | " | " | " | " 11 ... | 8-30a | 5 33.4 " |
| Lake St. Joseph..... | 51 11.2 | 90 37.0 | 1885 | Sept. 6.... | 9-30a | 5 22.0 " |
| "..... | " | " | " | " 6.... | 4-10p | 5 18.8 " |
| ".....* | 50 58.8 | 91 08.0 | " | Aug. 29.... | 5-50p | 24 27.2 " |
| ".....* | " | " | " | " 30.... | 10-17a | 23 43.9 " |
| On a portage, Root river..... | 50 49.7 | 91 22.7 | 1885 | Aug. 23.... | 8-00a | 7 20.3 E |
| " "..... | " | " | " | " 23.... | 4-10p | 7 07.5 " |
| Cat river..... | 51 05.7 | 91 24.2 | " | Sept. 20 .. | 10-15a | 5 35.3 " |
| "..... | " | " | " | " 20.... | 3-33p | 5 35.0 " |
| Root river..... | 50 41.2 | 91 35.8 | " | Aug. 16 ... | 10-00a | 6 55.7 " |
| "..... | " | " | " | " 16 ... | 3-15p | 6 50.6 " |
| H. B. Co.'s post, Cat lake..... | 51 44.3 | 91 46.2 | " | Sept. 30 ... | 4-00p | 4 50.1 " |
| " "..... | " | " | " | Oct. 1.... | 6-40a | 4 31.1 " |
| Cat river..... | 51 30.0 | 91 49.7 | " | Sept. 27 ... | 9-39a | 5 12.3 " |
| "..... | " | " | " | " 27.... | 4-13p | 4 43.2 " |
| Cat lake..... | 51 46.3 | 91 51.1 | " | ..... | ..... | ..... |
| "..... | " | " | " | | | |
| Lac Seul..... | 50 23.7 | 92 04.8 | " | Aug. 9.... | 9-20a | 8 22.4 E |
| "..... | " | " | " | " 9. . | 4-40p | 8 09.1 " |
| H. B. Co.'s post, Lac Seul .. | 50 19.5 | 92 14.4 | " | " 6.... | 4-30p | 7 03.9 " |
| " "..... | " | " | " | " 7.... | 10-00a | 7 09.4 " |
| At a creek..... | 58 02.0 | 92 20.0 | 1846 | ..... | ..... | ..... |
| York Factory..... | 56 59.9 | 92 26.0 | 1843 | July 24.... | 6-07p | 9 37.8 E |
| "..... | " | " | " | " 24.... | 6-40p | 9 07.8 " |
| "..... | " | " | " | " 26.... | 7-21a | 8 16.2 " |
| "..... | " | " | " | " 26.... | 7-36a | 9 00.8 " |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | 1845 | ..... | ..... | ..... |

* Local disturbance.

SESSIONAL PAPER No. 25a

VI—*Con.*RESULTS—*Con.*SURROUNDING TERRITORY—*Con.*

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|--------------------|--------------------|---------|--------------------|--------------------|--------------|---------------|-------------|---------------|
| July 27 | | 88 16.7 | | | | | | Dr. J. Rae. |
| | | 87 10.6 | | | | | | " |
| Aug. 3. | | 88 27.1 | | | | | | " |
| | | 86 36.5 | | | | | | " |
| July 8 | | 86 47.3 | | | | | | " |
| Sept. 10 | 4-12 to 4-55p | 80 18.3 | Sept. 10 | 5-00 to 5-25p | | 6481 | 60 | Th. Fawcett. |
| " 11. | 9-00 to 9-30a | 80 21.4 | " 11. | 9-35 to 10-00a | | 6484 | 56 | " |
| " 6. | 10-00 to 10-30a | 80 25.3 | " 6. | 10-35 to 11-00a | | 6450 | 52 | " |
| " 6. | 4-35 to 5-00p | 80 19.0 | " 6. | 5-55 to 6-20p | | 6463 | 48 | " |
| Aug. 29. | 6-10 to 6-38p | 81 46.6 | Aug. 29 | 6-40 to 7-04p | | 6435 | 55 | " |
| " 30. | 10-20 to 10-40a | 81 48.8 | " 30. | 11-55 to 12-13a | | 6413 | 61 | " |
| " 23. | 8-27 to 8-55a | 79 42.1 | Aug. 23. | 9-00 to 9-26a | | 6513 | 51 | " |
| " 23. | 4-26 to 4-54p | 79 39.4 | " 23. | 4-56 to 5-15p | | 6500 | 48 | " |
| Sept. 20. | 10-15 to 11-08a | 80 05.7 | Sept. 20. | 11-10 to 11-40a | | 6491 | 70 | " |
| " 20. | 4-03 to 4-30p | 80 04.5 | " 20 | 4-35 to 5-00p | | 6493 | 60 | " |
| Aug. 16. | 0-08 to 0-33p | 79 27.1 | Aug. 16 | 0-35 to 1-00p | | 6526 | 67 | " |
| " 16. | 3-28 to 3-52p | 79 26.1 | " 16 | 3-54 to 4-10p | | 6516 | 70 | " |
| Sept. 30. | 4-00 to 4-30p | 80 29.0 | Sept. 30. | 4-32 to 5-00p | | 6497 | 46 | " |
| Oct. 1 | 7-40 to 8-10a | 80 29.0 | Oct. 1. | 8-18 to 8-42a | | 6475 | 47 | " |
| Sept. 27. | 10-02 to 10-24a | 80 11.6 | Sept. 27 | 10-25 to 11-00a | | 6533 | 67 | " |
| " 27. | 4-35 to 5-07p | 80 07.0 | " 27. | 5-09 to 5-25p | | 6548 | 61 | " |
| Oct. 1. | 3-26 to 4-15p | 80 24.6 | Oct. 1. | 4-20 to 5-07p | | 6538 | 55 | " |
| " 1. | 4-17p to 4-40 | 80 21.8 | " 1 | 5-08 to 5-30p | | 6523 | 55 | " |
| Aug. 9 | 5-35p to 6-07 | 79 03.9 | Aug. 9. | 5-38 to 6-00p | | 6557 | 72 | " |
| " 9. | 6-07 to 6-30p | 79 04.9 | " 9 | 10-36 to 11-00 | | 6539 | 70 | " |
| " 6. | 4-43 to 5-12p | 79 35.3 | " 6. | 5-18 to 5-40p | | 6534 | 70 | " |
| " 7. | 10-00 to 10-33a | 79 34.4 | " 7. | 10-35 to 11-00a | | 6537 | 69 | " |
| June 20. | | 84 46.4 | July 24. | | | 6492 | | Dr. J. Rae. |
| July 24. | 11-00a | 83 50.5 | " 24 | | | 6481 | | J. H. Lefroy. |
| " 24. | 3-00p | 83 44.0 | " 25. | | | 6500 | | " |
| | | | " 25. | | | 6433 | | " |
| | | | " 25. | | | 6460 | | " |
| | | | " 26. | | | 6495 | | " |
| | | | " 26. | | | 6494 | | " |
| Dec. 3. | | 83 54.2 | | | | | | Dr. J. Rae. |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC
HUDSON BAY AND

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--|-----------|------------|-------|----------------|--------------------|--------------|
| York Factory..... | 56 59.9 | 92 26.0 | 1846 | | | |
| " | " | " | 1847 | | | |
| " | " | " | 1857 | | | |
| " | " | " | " | | | |
| " | " | " | 1884 | Sept. 12.... | 10-15 to 11-53a | 6 45.0 E |
| " | " | " | " | " 13.... | 9-20 to 9-46a | 6 32.0 " |
| Shanty narrows, Lac Seul. | 50 29.3 | 92 51.57 | 1885 | Aug. 1.... | 5-33p | 6 54.7 " |
| " | " | " | " | " 2.... | 7-47a | 7 15.7 " |
| Jct. of the Shamattawa and Hayes rivers. | 56 21.0 | 93 00.0 | 1843 | July 22.... | 6-15p | 10 00.0 " |
| " | " | " | " | " 23.... | 4-03p | 12 19.6 " |
| " | " | " | " | | | |
| English river. | 50 38.9 | 93 10.2 | 1885 | July 29.... | 5-30p | 9 21.0 E |
| " | " | " | " | | | |
| Camping lake, English river... .. | 50 38.1 | 93 24.1 | " | July 26.... | 9-40a | 8 20.0 " |
| " | " | " | " | | | |
| White Mud portage | 55 33.0 | 93 44.6 | 1843 | July 31.... | 7-19a | 10 51.0 E |
| " | " | " | " | | | |
| " | " | " | " | | | |
| " | " | " | " | | | |
| Tide lake, English river. | 50 20.6 | 93 57.0 | 1885 | July 18.... | 6-15p | 9 24.8 E |
| " | " | " | " | " 19.... | 7-30a | 9 23.8 " |
| Devils Landing Place | 54 24.0 | 94 00.0 | 1844 | Aug. 1.... | 8-24a | 11 49.4 " |
| " | " | " | " | | | |
| Grassy narrows, English river.. | 50 10.7 | 94 02.2 | 1885 | July 15.... | 5-00p | 9 28.0 " |
| " | " | " | " | | | |
| Fort Churchill. | 58 43.8 | 94 14.0 | 1846 | June 29.... | a.m. | 12 43.0 E. |
| " | " | " | " | July 1.... | p.m. | 11 29.0 " |
| " | " | " | " | | | |
| " | " | " | " | | | |
| Long portage | 55 14.0 | 94 22.0 | 1819 | Sept. | | 11 10.4 E. |
| " | " | " | 1843 | July 20.... | 5-42a | 12 59.4 " |
| " | " | " | " | Aug. 2.... | 6-29a | 12 13.5 " |
| " | " | " | " | | | |
| " | " | " | " | | | |
| English river. | 50 16.0 | 94 30.6 | 1885 | July 12.... | 8-10a | 9 44.7 E. |
| " | " | " | " | | | |
| " | 50 21.8 | 94 39.3 | " | " 9.... | 6-00p | 10 21.2 E. |
| " | " | " | " | | | |
| " | 50 14.5 | 94 59.3 | " | July 5.... | 9-50a | 9 07.0 E. |

SESSIONAL PAPER No. 25a

VI—Con.

RESULTS—Con.

SURROUNDING TERRITORY—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|---------------|
| Feb. 9..... | | 83 42.9 | | | | | | Dr. J. Rae. |
| April 25..... | | 83 35.5 | | | | | | " |
| Sept. 18..... | | 83 47.0 | | | | | | " |
| Aug. 9..... | | 83 53.0 | | | | 6466 | | Blakiston. |
| | | | | | | 6463 | | " |
| Sept. 11..... | 3-05 | | | 3-45 | | | | |
| | to 3-40p | 83 47.2 | Sept. 11..... | to 4-10p | | 6419 | | Otto Klotz. |
| | 4-18 | | | 3-45 | | | | |
| " 11..... | to 4-56p | 83 46.7 | " 11..... | to 4-10p | | 6423 | | " |
| | 5-35 | | | 6-25 | | | | |
| Aug. 1..... | to 6-20p | 79 16.3 | Aug. 1..... | to 6-50p | | 6557 | 59 | Th. Fawcett. |
| | 8-00 | | | 9-00 | | | | |
| " 2..... | to 8-55a | 79 14.9 | " 2..... | to 9-32a | | 6520 | 78 | " |
| July 28..... | 4 00p | 83 36.2 | July 22..... | | | 6503 | | J. H. Lefroy. |
| " 22..... | | 83 41.6 | " 28..... | | | 6534 | | " |
| " 28..... | | 83 30.2 | " 22..... | | | 6504 | | " |
| | | | " 28..... | | | 6496 | | " |
| | 5-50 | | | 6-40 | | | | |
| July 29..... | to 6-30p | 79 10.8 | " 29..... | to 7-06p | | 6486 | 74 | Th. Fawcett. |
| | 7-36 | | | 7-36 | | | | |
| " 29..... | to 8-10p | 79 13.0 | " 29..... | to 8-10p | | 6474 | 71 | " |
| | 9-40 | | | 11-05 | | | | |
| " 26..... | to 11-00a | 79 16.1 | " 26..... | to 11-48a | | 6477 | 75 | " |
| | 4-00 | | | 4-30 | | | | |
| " 26..... | to 4-28p | 79 18.2 | " 26..... | to 5-06p | | 6463 | 67 | " |
| " 21..... | 1 00p | 83 02.9 | " 21..... | | | 6552 | | J. H. Lefroy. |
| " 21..... | | 83 11.6 | " 31..... | | | 6511 | | " |
| " 31..... | | 83 00.0 | " 21..... | | | 6484 | | " |
| | | | " 31..... | | | 6472 | | " |
| | 6-15 | | | 7-30 | | | | |
| July 18..... | to 7-25p | 79 20.0 | " 18..... | to 8-05p | | 6460 | 60 | Th. Fawcett. |
| | 9-30 | | | 10-40 | | | | |
| " 19..... | to 10-35a | 79 22.9 | " 19..... | to 11-25a | | 6486 | 63 | " |
| Aug. 1..... | | 82 55.0 | Aug. 1..... | | | 6576 | | J. H. Lefroy. |
| | | | " 1..... | | | 6512 | | " |
| | 5-00 | | | 6-00 | | | | |
| July 15..... | to 5-50p | 79 09.3 | July 15..... | to 6-30p | | 6429 | 74 | Th. Fawcett. |
| | 7-30 | | | 8-15 | | | | |
| " 15..... | to 8-00p | 79 02.5 | " 15..... | to 8-50p | | 6471 | 65 | " |
| June 29..... | | 84 57.5 | | | | | | Dr. J. Rae. |
| " 29..... | | 84 44.2 | | | | | | " |
| July 1..... | | 84 33.9 | | | | | | " |
| " 1..... | | 84 53.8 | | | | | | " |
| " 4..... | | 84 44.5 | | | | | | " |
| July 19..... | 4-30p | 82 13.9 | July 20..... | | | 6543 | | Franklin. |
| " 20..... | | 82 21.3 | Aug. 2..... | | | 6566 | | J. H. Lefroy. |
| Aug. 2..... | | 82 32.2 | " 2..... | | | 6540 | | " |
| | | | July 20..... | | | 6568 | | " |
| | | | Aug. 2..... | | | 6534 | | " |
| | 9-06 | | | 10-25 | | | | |
| July 12..... | to 9-45a | 79 19.0 | July 12..... | to 10-46 | | 6405 | 83 | Th. Fawcett. |
| | 10-50 | | | 0-00 | | | | |
| " 12..... | to 11-52a | 79 13.6 | " 12..... | to 0-35p | | 6414 | 75 | " |
| | 6-00 | | | 7-30 | | | | |
| " 9..... | to 7-00p | 79 25.9 | " 9..... | to 7-55p | | 6435 | 54 | " |
| | 8-00 | | | 7-00 | | | | |
| " 9..... | to 8-40p | 79 18.7 | " 10..... | to 7-20a | | 6457 | 64 | " |
| | 9-15 | | | 0-10 | | | | |
| " 5..... | to 11-10a | 79 08.0 | " 5..... | to 9-32p | | 6464 | 89 | " |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

HUDSON BAY AND

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---|-----------|------------|-------|-------------------|------------------------|--------------|
| | ° ' " | ° ' " | | | | ° ' " |
| *Oxford House..... | 54 56·0 | 95 30·0 | 1843 | Aug. 3.... | 5-10p | 10 31·5 E. |
| "..... | " " | " " | " | " | " | " |
| Hell Gate, Upper portage..... | 54 42·0 | 96 10·0 | " | " | " | " |
| " "..... | " " | " " | " | " | " | " |
| " "..... | " " | " " | " | " | " | " |
| East end Split lake, Nelson river..... | 56 13·3 | 96 18·8 | 1884 | " | " | " |
| South end of White Fall port- age..... | 54 23·3 | 96 31·0 | 1843 | Aug. 5.... | 3-36p | 17 32·0 E. |
| South end of White Fall port- age..... | " | " | " | " | " | " |
| Nelson river..... | 55 20·8 | 97 06·3 | 1884 | " | " | " |
| Hairy lake, mouth of R. Echi- mamish..... | 54 20·0 | 97 28·0 | 1843 | July 15.... | 4-00p | 18 43·7 E. |
| Hairy lake, mouth of R. Echi- mamish..... | " | " | " | " | " | " |
| Nelson river, on an island of granite..... | 54 16·8 | 97 46·4 | 1884 | July 27.... | 5-40p | 16 11·0 E. |
| Nelson river..... | 54 50·1 | 98 11·8 | 1884 | " | " | " |
| Duck Nest, Lake Winnipeg... | 53 15·5 | 97 33·5 | 1886 | Aug. 3.... | 8-45a | 16 41·6 E. |
| " "..... | " | " | " | " | " | " |
| Old Norway House..... | 53 41·6 | 98 01·4 | 1819 | " | " | " |
| "..... | " | " | 1843 | " | " | " |
| "..... | " | " | " | " | " | " |
| "..... | " | " | " | " | " | " |
| Norway House..... | 53 59·6 | 98 03·9 | 1843 | July 13 .. | 6-45p | 16 21·9 E. |
| "..... | " | " | " | " 13 .. | 7-04p | 16 00·0 " |
| "..... | " | " | " | " 13 .. | 7-10p | 15 58·6 " |
| "..... | " | " | " | " 13 .. | 7-30p | 15 12·1 " |
| "..... | " | " | " | " | " | " |
| "..... | " | " | 1844 | Sept. 6... 5-22p | 14 51·0 E. | |
| "..... | " | " | " | " 7... 9-12a | 15 22·0 " | |
| "..... | " | " | " | " | " | " |
| "..... | " | " | " | " | " | " |
| "..... | " | " | 1884 | July 22.... | 4-30p | 14 55·0 E. |
| "..... | " | " | " | " 24.... | 4-30p | 14 59·0 " |
| "..... | " | " | " | Oct. 4.... | 3-15p | 15 00·0 " |
| "..... | " | " | " | " | " | " |

* Local disturbance.

SESSIONAL PAPER No. 25a

VI—Con.

RESULTS—Con.

SURROUNDING TERRITORY—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | * Total intens. | Tem- perature | Observer. |
|-------------------|------------------------|---------|-------------------|------------------------|-----------------|--------------------|------------------|----------------|
| Aug. 3.... | 5-30p | 82 38'8 | Aug. 3.... | | | 6568 | | J. H. Lefroy. |
| " 3.... | | 82 43'4 | " 3.... | | | 6542 | | " |
| " 3.... | | | " 3.... | | | 6548 | | " |
| Aug. 4.... | 1-30p | 81 57'0 | " 4.... | | | 6557 | | " |
| " 4.... | | 81 53'5 | " 4.... | | | 6540 | | " |
| " 4.... | | | " 4.... | | | 6544 | | " |
| " 4.... | | | " 4.... | | | 6509 | | " |
| Aug. 17.... | 4-10 to 4-55p | 82 49'9 | " 17.... | 5-05 to 5-39p | | 6453 | 61 | Otto Klotz. |
| " 5.... | 1-00p | 81 47'9 | " 5.... | | | 6557 | | J. H. Lefroy. |
| " 5.... | | 81 51'6 | " 5.... | | | 6524 | | " |
| " 10.... | 4-45 to 5-25p | 81 58'1 | " 10.... | 5-30 to 5-55p | | 6593 | 68 | Otto Klotz. |
| July 15.... | 4-30p | 81 20'9 | July 15.... | | | 6487 | | J. H. Lefroy. |
| " 15.... | | | " 15.... | | | 6483 | | " |
| July 27.... | 3-45 to 4-35p | 81 23'8 | " 27.... | 4-45 to 5-15p | | 6512 | 69 | Otto Klotz. |
| Aug 3.... | 5-34 to 6-13p | 82 24'3 | Aug. 3.... | 6-17 to 6-44p | | 6428 | 67 | " |
| " 3.... | 9-00 to 10-00a | 80 50'8 | " 3.... | 10-30 to 11-30a | | 5996 | | F. W. Wilkins. |
| " 3.... | 1-30 to 2-30p | 80 46'8 | " 3.... | 2-45 to 3-30p | | 6026 | | " |
| Oct. 7.... | | 83 40'0 | Aug. 12.... | | | 6506 | | Franklin. |
| Aug. 12.... | | 80 45'4 | " 12.... | | | 6552 | | J. H. Lefroy. |
| " 12.... | | 80 49'4 | " 12.... | | | 6551 | | " |
| July 12.... | | 81 11'0 | July 13.... | | | 6536 | | " |
| " 13.... | | 81 06'2 | Aug. 8.... | | | 6522 | | " |
| Aug. 9.... | | 81 09'4 | " 8.... | | | 6531 | | " |
| " 9.... | | | " 9.... | | | 6503 | | " |
| " 9.... | | | July 14.... | | | 6514 | | " |
| " 9.... | | | " 14.... | | | 6513 | | " |
| Sept. 7.... | a.m. | 81 11'1 | Sept. 6.... | | | 6475 | | " |
| " 7.... | | 81 11'4 | " 6.... | | | 6515 | | " |
| " 7.... | | | " 6.... | | | 6540 | | " |
| " 7.... | | | " 6.... | | | 6530 | | " |
| " 7.... | | | " 6.... | | | 6560 | | " |
| July 23.... | 2-43 to 3-32p | 81 05'4 | July 23.... | 3-40 to 4-06p | | 6525 | 80 | Otto Klotz. |
| " 23.... | 4-12 to 4-59p | 81 12'0 | " 23.... | 5-02 to 5-19p | | 6489 | 70 | " |
| " 23.... | 9-30 to 10-45a | 81 18'0 | " 23.... | 10-50 to 11-15a | | 6459 | 52 | " |
| Oct. 4.... | 0-00 to 0-50p | 81 15'8 | Oct. 4.... | 1-00 to 1-20p | | 6463 | 53 | " |

9-10 EDWARD VII., A. 1912

TABLE
MAGNETIC

C.I.—Carnegie Institution.

MANI

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--|-----------|------------|--------|----------------|------------------|--------------|
| | D M | C M | | | | C M |
| Winnipeg river..... | 50 10.2 | 95 12.0 | 1843 | June 21..... | 5-12p | 12 28.7 E |
| Slave falls..... | 50 14.7 | 95 40.0 | 1843 | | | |
| Badger..... | 49 12.0 | 95 56.0 | 1906 8 | | | 11 05.0 " |
| Fort Alexander..... | 50 36.9 | 96 22.0 | 1825 | June 5..... | | 15 15.7 " |
| "..... | " | " | 1834 | | | |
| "..... | " | " | 1843 | June 23..... | 6-37p | 13 29.0 " |
| "..... | " | " | " | " 26..... | 4-49a | 14 25.3 " |
| "..... | " | " | 1844 | Sept. 20..... | 7-33a | 14 03.4 " |
| "..... | " | " | " | " 20..... | 8-26a | 14 04.2 " |
| *Big island, Lake Winnipeg .. | 51 04.0 | 96 26.0 | 1844 | | | |
| "..... | " | " | " | | | |
| Bay of Winnipeg river, Lake Winnipeg..... | 50 41.7 | 96 31.4 | 1886 | June 23..... | 9-00a | 12 40.2 " |
| " " "..... | " | " | " | | | |
| Lake Winnipeg..... | 50 35.0 | 96 35.6 | 1843 | June 26..... | 6-06p | 13 41.0 " |
| "..... | 50 33.4 | 96 36.0 | 1843 | | | |
| About six miles N. of Loon creek, Lake Winnipeg..... | 51 36.9 | 96 37.3 | 1886 | July 9.... | 8 45a | 14 41.6 " |
| " " "..... | " | " | " | | | |
| *Lake Winnipeg, on an island. | 51 34.0 | 96 43.0 | 1844 | Sept. 17. | 9-36a | 15 06.7 " |
| " " "..... | " | " | " | | | |
| Selkirk..... | 50 09.2 | 96 51.8 | 1886 | | | |
| "..... | " | " | " | | | |
| On Red river .. | 50 18.2 | 96 52.0 | 1843 | | | |
| West Selkirk..... | 50 10.0 | 96 52.0 | 1907 8 | | | 13 16.8 " |
| *Opposite Bull's Head, Lake Winnipeg..... | 51 36.7 | 96 53.0 | 1843 | July 6. | 7-59a | 16 25.1 " |
| On Red river..... | 51 36.0 | 96 56.0 | 1843 | July 5. | 6-53p | 13 40.9 " |
| "..... | " | " | " | " 5..... | 7-05p | 13 10.5 " |
| "..... | " | " | " | July 5..... | 7-19p | 14 04.2 " |
| Island east of Bear island, Lake Winnipeg..... | 51 46.0 | 97 00.0 | 1843 | | | |
| " " "..... | " | " | " | | | |
| *Lake Winnipeg..... | 51 44.5 | 97 02.0 | 1844 | Sept. 16..... | 9-00a | 15 24.2 " |
| "..... | " | " | " | | | |
| Winnipeg..... | 49 52.0 | 97 09.0 | 1906 7 | | | 13 56.1 " |
| Lake Winnipeg..... | 52 20.9 | 97 10.0 | 1844 | Sept. 14..... | 3-48p | 16 54.6 " |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |

* Local disturbance.

SESSIONAL PAPER No. 25a

VII.

RESULTS.

TOBA.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|----------------|
| June 21. | " | 79 10.0 | June 21. | | | 6549 | | J. H. Lefroy. |
| " 21. | | 79 11.3 | | | | | | " |
| June 23. | | 78 57.1 | June 23. | | | 6498 | | " |
| " 23. | | 78 56.0 | | | | | | " |
| | | 77 36.4 | | | 1369 | | | C. I. |
| June 5. | | 78 47.1 | | | | | | Franklin. |
| | | 78 54.0 | | | | | | Back. |
| June 25. | | 78 51.8 | June 25. | | | 6477 | | J. H. Lefroy. |
| " 25. | | 78 55.8 | | | | | | " |
| Sept. 30. | | 79 03.4 | Sept. 19. | | | 6561 | | " |
| " 30. | | 79 02.5 | " 19. | | | 6564 | | " |
| | | | " 19. | | | 6527 | | " |
| Sept. 18. .. | a. m. | 79 31.5 | Sept. 18. | | | 6685 | | " |
| | | | " 18. | | | 6688 | | " |
| | | | " 18. | | | 6765 | | " |
| | 9-30 | | | 10-45 | | | | |
| June 23. | to 10-30a | 78 59.4 | June 23. | to 11-45a | | 5999 | 71 | F. W. Wilkins. |
| | 1-30 | | | 2-45 | | | | |
| " 23. | to 2-20p | 78 58.2 | " 23. | to 3-45p | | 5964 | 70 | " |
| June 26. | 7-00p | 78 34.4 | June 26. | | | 6514 | | J. H. Lefroy. |
| " 27. | | 79 05.1 | | | | | | " |
| | 0-15 | | | 1-45 | | | | |
| July 9. | to 1-30p | 78 49.5 | July 9. | to 2-30p | | 5981 | 78 | F. W. Wilkins. |
| | 9-00 | | | 10-30 | | | | |
| " 9. | to 10-00a | 78 48.9 | " 9. | to 11-15a | | 6004 | 72 | " |
| Sept. 17. | | 79 06.1 | Sept. 17. | | | 6646 | | J. H. Lefroy. |
| | | | " 17. | | | 6623 | | " |
| | | | " 17. | | | 6639 | | " |
| | 12-00 | | | 1-30 | | | | |
| June 7. | to 1-15p | 78 22.8 | June 7. | to 3-00p | | 6908 | 69 | F. W. Wilkins. |
| | 9-00 | | | 11-00 | | | | |
| " 8. | to 10-40a | 78 20.6 | " 8. | to 12-00a | | 6025 | 70 | " |
| July 4. | | 78 34.0 | July 4. | | | 6492 | | J. H. Lefroy. |
| | | 78 45.6 | " 4. | | | 6515 | | " |
| | | | | | 1256 | | | C. I. |
| July 6. .. | 6-30p | 79 38.0 | July 6. | | | 6660 | | J. H. Lefroy. |
| | | | " 6. | | | 6687 | | " |
| July 5. | 8-00p | 79 11.8 | July 5. | | | 6490 | | " |
| " 5. | | 79 01.2 | " 5. | | | 6514 | | " |
| | | | | | | | | " |
| July 7. | 1-00p | 79 28.3 | July 7. | | | 6638 | | " |
| " 7. | | 79 28.8 | " 7. | | | 6638 | | " |
| " 7. | | 79 32.2 | " 7. | | | 6649 | | " |
| Sept. 16. | | 79 39.0 | Sept. 16. | | | 7074 | | " |
| | | | " 16. | | | 7091 | | " |
| | | | " 16. | | | 7112 | | " |
| | | 78 10.3 | | | 1304 | | | C. I. |
| Sept. 14. | | 80 24.4 | Sept. 14. | | | 6633 | | J. H. Lefroy. |
| | | | " 14. | | | 6655 | | " |
| | | | " 14. | | | 6625 | | " |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

C. I.—Carnegie Institution.

MANI

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---|-----------|------------|---------|----------------------------|------------------------|--------------|
| Wesleyan Mission, Berens riv. | 52 22.6 | 97 13.0 | 1843 | July 8.... | 6-52p | 14 13.3 E |
| Fort Garry..... | 49 53.2 | 97 15.6 | 1843 | " 8..... | 7-04p | 14 20.7 " |
| " | " | " | " | June 29.... | 5-11p | 15 27.6 " |
| " | " | " | " | " 30..... | 7-18p | 16 42.1 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Winnipeg, C.P.R. station..... | 49 53.5 | 97 08.0 | 1882 | " | " | " |
| Winnipeg..... | 49 52.0 | 97 09.0 | 1908 | July 16, 17, 18, 20.... | 10-30a | 13 58.6 |
| Near Leaf river, Lake Winni- peg..... | 52 31.6 | 97 18.0 | 1843 | July 10.... | 8-03a | 19 12.2 E |
| " " "..... | " | " | " | " | " | " |
| " " "..... | " | " | " | " | " | " |
| " " "..... | " | " | " | " | " | " |
| Four miles south of War Path river, Lake Winnipeg..... | 52 18.3 | 98 14.6 | 1886 | Sept. 22.... | 9-00a | 15 48.4 " |
| " " "..... | " | " | " | " | " | " |
| End of Long point, Lake Winnipeg..... | 53 02.5 | 98 27.5 | 1886 | Sept. 9.... | 8-45a | 15 39.1 " |
| " " "..... | " | " | " | " | " | " |
| North side of Long point, Lake Winnipeg..... | 53 04.2 | 98 44.5 | 1886 | Sept. 6.... | 8-45a | 17 31.8 " |
| " " "..... | " | " | " | " | " | " |
| North end of Limestone bay, Lake Winnipeg..... | 53 53.8 | 98 48.7 | 1886 | Aug. 19.... | 8-15a | 15 13.8 " |
| " " "..... | " | " | " | " | " | " |
| Lake Winnipeg..... | 53 31.9 | 99 12.0 | 1843 | Aug. 14.... | 8-14a | 17 07.3 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Grand Rapids, east end..... | 53 08.4 | 99 27.0 | 1843 | Aug. 15.... | 4-14p | 19 12.9 " |
| " " "..... | " | " | 1844 | Sept. 2.... | 9-43a | 17 25.0 " |
| " " "..... | " | " | " | " | " | " |
| " " "..... | " | " | " | " | " | " |
| H. B. Co's. post, Grand Rapids | 53 13.4 | 99 29.0 | 1884 | July 17.... | 6-15p | 15 38.0 " |
| Cross lake..... | 53 10.1 | 99 34.0 | 1843 | Aug. 16.... | 9-34a | 18 03.7 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Brandon..... | 49 50.0 | 99 57.0 | 1884 | July 18.... | 5-42p | 14 46.5 " |
| " | " | " | " | " 19.... | 9-02a | 15 06.8 " |
| " | " | " | " | " 19.... | 11-32a | 14 47.0 " |
| " | 49 52.0 | 99 58.0 | 1906-7 | " | " | 15 00.2 " |

SESSIONAL PAPER No. 25a

VII—Con.

RESULTS—Con.

TORA—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. Intens. | Total Intens. | Temperature | Observer. |
|---------------------------|------------------|---------|---------------------------|------------------|--------------|---------------|-------------|----------------|
| July 8. | 7-00p | 80 39.2 | July 8. | | | 6524 | | J. H. Lefroy. |
| " 8. | | 80 28.9 | | | | | | " |
| July 3. | | 78 19.4 | June 29. | | | 6498 | | " |
| " 3. | | 78 16.3 | " 29. | | | 6492 | | " |
| June 29. | | 78 17.0 | " 29. | | | 6466 | | " |
| " 29. | | 78 10.0 | " 29. | | | 6465 | | " |
| July 3. | | 78 10.7 | " 29. | | | 6462 | | " |
| | | | " 29. | | | 6486 | | " |
| | | | " 30. | | | 6457 | | " |
| | | | July 1. | | | 6459 | | " |
| May. | | 79 50.7 | | | | | | Wm. Ogilvie. |
| " | | 79 49.9 | | | | | | " |
| July 16, 17, 18, 20. | | 78 13.0 | July 16, 17, 18, 20. | | 13121 | | | C. A. French. |
| July 10. | | 80 03.7 | July 10. | | | 6510 | | J. H. Lefroy. |
| " 10. | 2-03p | 80 07.2 | " 10. | | | 6509 | | " |
| " 10. | | 80 08.2 | " 10. | | | 6534 | | " |
| | | | " 10. | | | 6485 | | " |
| | | | " 10. | | | 6524 | | " |
| | 9-10 | | | 10-15 | | | | |
| Sept. 22. | to 10-00a | 79 43.9 | Sept. 22. | to 11-00a | | 5996 | 50 | F. W. Wilkins. |
| | 11-15 | | | 0-45 | | | | |
| " 22. | to 12-15a | 79 47.4 | " 22. | to 1-30p | | 5953 | 55 | " |
| | 9-00 | | | 10-15 | | | | |
| Sept. 9. | to 10-00a | 80 26.5 | Sept. 9. | to 11-00a | | 5986 | 61 | " |
| | 10-15 | | | 11-13 | | | | |
| " 9. | to 11-15a | 80 23.4 | " 9. | to 12-15p | | 5992 | 62 | " |
| | 9-00 | | | 10-30 | | | | |
| Sept. 6. | to 10-00a | 81 01.5 | Sept. 6. | to 11-15a | | 5983 | 68 | " |
| | 10-30 | | | 0-45 | | | | |
| " 6. | to 12-15a | 80 58.9 | " 6. | to 1-30p | | 5988 | 70 | " |
| | 8-30 | | | 9-45 | | | | |
| Aug. 19. | to 9-30a | 81 03.4 | Aug. 19. | to 10-30a | | 5941 | 68 | " |
| | 10-45 | | | 11-40 | | | | |
| " 19. | to 11-30a | 80 58.1 | " 19. | to 12-15a | | 5984 | 69 | " |
| Aug. 14. | 5-00a | 80 16.8 | Aug. 14. | | | 6533 | | J. H. Lefroy. |
| " 14. | 5-00a | 80 19.7 | " 14. | | | 6483 | | " |
| " 14. | | 80 30.0 | " 14. | | | 6486 | | " |
| | | | " 14. | | | 6500 | | " |
| Aug. 15. | 6-30p | 80 21.5 | Aug. 15. | | | 6540 | | " |
| | | | " 15. | | | 6494 | | " |
| Sept. 2. | 6-30a | 80 31.6 | Sept. 2. | | | 6547 | | " |
| | | | " 2. | | | 6517 | | " |
| | | | " 2. | | | 6496 | | " |
| | | | " 2. | | | 6494 | | " |
| | 4-25 | | | 5-05 | | | | |
| July 19. | to 5-05p | 80 24.9 | July 19. | to 5-25p | | 6503 | | O. Klotz. |
| Aug. 16. | | 80 28.2 | Aug. 16. | | | 6546 | | J. H. Lefroy. |
| | | | " 16. | | | 6474 | | " |
| | | | " 16. | | | 6549 | | " |
| | | | " 16. | | | 6557 | | " |
| | | | " 16. | | | 6541 | | " |
| | | | " 16. | | | 6537 | | " |
| | | | " 16. | | | 6573 | | " |
| | 3-20 | | | 4-45 | | | | |
| July 18. | to 4-20p | 77 34.9 | July 18. | to 5-55p | | 6459 | 72 | E. Deville. |
| | 10-00 | | | 11-15 | | | | |
| " 19. | to 11-00a | 77 37.0 | " 19. | to 12-00a | | 6453 | 82 | " |
| | | | | | | | | " |
| | | 77 28.7 | | | 1381 | | | C. I. |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC

C. I.—Carnegie Institution.

MANI

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--|-----------|------------|--------|-------------------|------------------------|--------------|
| Hare island, Cedar lake..... | 53 12.2 | 100 00 0 | 1843 | | | |
| Chemahawin, Saskatchewan river..... | 53 20.4 | 100 32.2 | 1884 | July 5..... | 8-00p | 17 36.0 " |
| Devil's Drum island, Saskat- chewan R. | 53 19.5 | 100 36.0 | 1843 | Aug. 9 | 7-30p | 17 32.2 " |
| " " " | " " | " " | " | | | |
| Lauder. | 49 24.0 | 100 43.0 | 1906-7 | | | 16 09.5 " |
| On bank of Saskatchewan river | 53 52.6 | 101 11.0 | 1884 | | | |
| Kirkella. | 50 02.0 | 101 22.0 | 1906-7 | | | 16 02.4 " |
| Round Turn, Saskatchewan river..... | 53 48.8 | 101 23.0 | 1844 | Aug. 31.... | 10-39a | 19 56.8 " |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| On bank of Saskatchewan river | 54 02.2 | 101 34.9 | 1844 | June 22.... | 7-00p | 19 22.0 " |
| Sturgeon Weir river..... | 54 20.9 | 101 42.9 | 1888 | Oct. 7..... | 9-50a | 18 27.3 " |
| At Swan River Barracks... .. | 51 54.4 | 101 57.3 | 1880 | June 12.... | 1-00p | 19 37.3 " |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |

SESSIONAL PAPER No. 25a

VII—*Con.*RESULTS—*Con.*TOBA—*Con.*

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Tem- perature | Observer. |
|-------------------|------------------------|---------|-------------------|------------------------|-----------------|------------------|------------------|---------------|
| Aug. 18.... | 1-25 | 80 07.1 | Aug. 18.... | 2 25 | | 6484 | | J. H. Lefroy. |
| July 7.... | to 2-19p | 80 04.4 | July 7.... | to 2-48p | | 6487 | | O. Klotz. |
| Aug. 19.... | | 80 00.0 | Aug. 19.... | | | 6393 | | J. H. Lefroy. |
| | | | " 19.... | | | 6356 | | " |
| | | | " 19.... | | | 6358 | | " |
| | 6-08 | 76 53.7 | | 6-54 | | 1433 | | C. I. |
| June 28.... | to 6-50p | 80 20.2 | June 28.... | to 7-20p | | 6463 | 56 | O. Klotz. |
| | | 77 17.0 | | | | 1400 | | C. I. |
| Aug. 31.... | | 80 24.4 | Aug. 31.... | | | 6600 | | J. H. Lefroy. |
| | | | " 31.... | | | 6502 | | " |
| | | | " 31.... | | | 6614 | | " |
| June 22.... | 5-30 | | June 22.... | 6-20 | | | | |
| | to 6-13p | 80 20.3 | | to 6-50p | | 6466 | 81 | O. Klotz. |
| | 10-30 | | | 11-27 | | | | |
| Oct. 7.... | to 10-55a | 80 16.3 | Oct. 7.... | to 11-45a | | 6470 | 60 | Th. Fawcett. |
| | 11-15 | | | | | | | |
| June 12.... | to 11-50a | 78 33.4 | | | | | | W. F. King. |
| | 7-30 | | | | | | | |
| June 7 & 8.... | to 8-15p | 78 38.4 | | | | | | " |
| | 2-00 | | | | | | | |
| | to 2-30p | | | | | | | |
| | 9-45 | | | | | | | |
| " 13.... | to 10-30a | 78 36.0 | | | | | | " |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC
SASKATCHEWAN

C. I.—Carnegie Institution.

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---------------------------------|-----------|------------|--------|-------------------|------------------------|--------------|
| On Ellice and Touchwood trail | 50 42'5 | 102 00'0 | 1880 | May 22.... | 11-00a | 18 51'0 E. |
| " " " | " " | " " | " | " 22.... | 2-00p | 18 55'0 " |
| " " " | " " | " " | " | " 27.... | 4-00p | 18 48'0 " |
| " " " | " " | " " | " | " 31.... | 11-00a | 18 48'0 " |
| On Pelly and Qu'Appelle trail. | 51 44'8 | 102 00'8 | " | June 16.... | 7-00p | 20 10'0 " |
| " " " | " " | " " | " | " 17.... | 6-00p | 20 15'0 " |
| Limestone point, Beaver lake.. | 54 26'0 | 102 10'0 | 1843 | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| Cumberland House. | 53 56'7 | 102 19'2 | 1819 | Nov. 19.... | | 17 17'5 E. |
| " " " | " " | " " | 1825 | May 22.... | | 19 14'3 " |
| " " " | " " | " " | 1843 | Aug. 23.... | 7-30a | 19 52'4 " |
| " " " | " " | " " | " | " 23.... | 7-58a | 19 43'8 " |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | 1844 | Aug. 29.... | 5-30p | 19 16'7 E. |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | 1884 | June 17.... | 6-00p | 20 09'0 E. |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | 1888 | Oct. 14.... | 2-30p | 19 19'1 E. |
| " " " | " " | " " | " | " 14.... | 2-40p | 19 37'9 " |
| Broadview..... | 50 24'0 | 102 35'0 | 1906-7 | | | 17 05'7 " |
| Carp portage, Great river.... | 54 47'2 | 102 39'5 | 1843 | Aug. 27.... | 2-23p | 24 08'6 " |
| Fine portage | 55 04'0 | 102 42'0 | 1843 | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| " " " | " " | " " | " | | | |
| Estevan..... | 49 09'0 | 102 58'0 | 1906-7 | | | 17 29'4 E. |
| Northeast of Beaver hills | 51 38'7 | 103 08'0 | 1880 | June 21.... | 5-30p | 19 30'0 " |
| " " " | " " | " " | " | " 22.... | 4-30p | 19 30'0 " |
| " " " | " " | " " | " | " 25.... | 7-30p | 19 41'0 " |
| Frog portage. | 55 24'1 | 103 15'2 | 1888 | Sept. 21. . | 1-55p | 21 10'8 " |
| " " " | " " | " " | " | " 21.... | 2-10p | 20 30'4 " |
| On an island, Saskatchewan riv. | 53 38'2 | 103 41'9 | 1884 | June 8. | 8-00a | 20 25'0 " |
| Northwest of Beaver hills..... | 51 32'0 | 103 42'6 | 1880 | " 27.... | 6-30p | 19 45'0 " |

SESSIONAL PAPER No. 25a

VIII.

RESULTS.

AND ALBERTA.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|--------------------|---------|----------------|--------------------|--------------|---------------|-------------|---------------|
| May 23. | 11-00 to 12-00a | 78 00.5 | | | | | | W. F. King. |
| " 24. | 7-00 to 7-45p | 77 51.6 | | | | | | " |
| " 27. | 5-00 to 6-00p | 77 42.5 | | | | | | " |
| June 16 | 7-15 to 7-45p | 78 34.8 | | | | | | " |
| Aug. 26. | 2-00 to 3-00p | 80 34.2 | Aug. 26. | | | 6501 | | J. H. Lefroy. |
| | | | " 26. | | | 6421 | | " |
| | | | " 26. | | | 6501 | | " |
| | | | " 26. | | | 6436 | | " |
| | | | " 26. | | | 6408 | | " |
| June 28. | | 80 21.1 | | | | | | Franklin. |
| Aug. 23. | 7-00a | 80 28.2 | Aug. 23. | | | 6504 | | J. H. Lefroy. |
| " 23. | | 80 31.8 | " 23. | | | 6535 | | " |
| | | | " 23. | | | 6460 | | " |
| | | | " 24. | | | 6532 | | " |
| | | | " 24. | | | 6534 | | " |
| | | | " 24. | | | 6522 | | " |
| | | | " 24. | | | 6519 | | " |
| | | | " 24. | | | 6527 | | " |
| | | | " 23. | | | 6552 | | " |
| | | | " 23. | | | 6551 | | " |
| | | | " 23. | | | 6530 | | " |
| Aug. 29. | p.m. | 80 20.5 | " 23. | | | 6528 | | " |
| " 29. | p.m. | 80 19.5 | " 29. | | | 6530 | | " |
| | " | | " 29. | | | 6543 | | " |
| | | | " 29. | | | 6470 | | " |
| June 17. | 9-43 to 10-23a | 80 24.3 | June 17. | 10-40 to 11-05a | | 6383 | 84 | Otto Klotz. |
| " 17. | 4-07 to 4-44p | 80 28.4 | " 17. | 4-48 to 5-11p | | 6457 | 80 | " |
| Oct. 14 | 2-44 to 3-10p | 80 26.4 | Oct. 14. | 3-10 to 4-00p | | 6476 | | Th. Fawcett. |
| " 14 | 3-12 to 3-33p | 80 21.4 | " 14. | 4-00 to 4-15p | | 6454 | | " |
| Aug. 27. | 77 37.5 1-30p | 80 39.6 | | | 1359 | | | C. I. |
| " 28. | 80 52.7 11-00a | | Aug. 28. | | | 6532 | | J. H. Lefroy. |
| | | | " 28. | | | 6473 | | " |
| | | | " 28. | | | 6518 | | " |
| | | | " 28. | | | 6501 | | " |
| | | | " 28. | | | 6465 | | " |
| | | 76 18.3 | | | 1490 | | | C. I. |
| June 23 | 5-00 to 5-30p | 78 21.4 | | | | | | W. F. King. |
| " 24. | 8-30 to 9-10p | 78 21.1 | | | | | | " |
| Sept. 21. | 2-37 to 3-00p | 81 00.7 | Sept. 21. | 3-09 to 3-23p | | 6451 | 60 | Th. Fawcett. |
| " 21. | 3-44 to 4-10p | 80 59.1 | " 21. | 3-25 to 3-36p | | 6447 | 60 | " |
| June 8. | 5-55 to 6-29p | 79 49.7 | June 8. | 6-35 to 6-57p | | 6474 | 66 | Otto Klotz. |
| " 26. | 0-00 to 1-00p | 78 18.7 | | | | | | W. F. King. |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

C. I.—Carnegie Institution.

SASKATCHEWAN

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---|-----------|------------|--------|----------------|------------------|--------------|
| Northwest of Beaver hills... | 51 32 0 | 103 42 6 | 1880 | June 28.... | 7-00a | 20 00 0 E. |
| " " " | " | " | " | " | " | " |
| Fort Qu'Appelle..... | 50 46 3 | 103 48 1 | " | July 5..... | 3-00p | 19 30 0 " |
| " " " | " | " | " | " 10..... | 7-30a | 19 40 0 " |
| On Touchwood and Qu'Appelle trail..... | 51 12 5 | 103 53 8 | " | June 30. . | 7-30p | 19 50 0 " |
| " " " | " | " | " | July 1..... | 5-00a | 19 50 0 " |
| Touchwood hills, H. B. Co's post..... | 51 21 6 | 104 00 0 | " | June 28.... | 6-00p | 18 33 6 " |
| On bank, Saskatchewan river.. | 53 18 7 | 104 04 7 | 1884 | " | " | " |
| H. B. Co's post, Stanley..... | 55 25 4 | 104 18 9 | 1888 | Sept. 15.. | 8-10a | 23 38 2 E. |
| " " " | " | " | " | " 15.... | 8-30a | 22 53 9 " |
| Mountain portage..... | 55 33 4 | 104 19 2 | " | " 13.... | 3-40p | 20 10 7 " |
| " " " | 55 33 4 | 104 19 2 | " | " 13.... | 3-50p | 21 04 1 " |
| * Little Rock Portage..... | 55 30 0 | 104 34 0 | 1843 | Aug. 31.... | 4-18p | 16 35 0 " |
| " " " | " | " | " | " 31.... | 4-51p | 15 16 3 " |
| " " " | " | " | " | " 31.... | 5-10p | 17 01 4 " |
| Regina. | 50 27 4 | 104 35 0 | 1884 | July 21.... | 9-07a | 18 44 8 " |
| " " " | " | " | " | " 21.... | 9-07p | 18 32 3 " |
| " " " | " | " | " | " 21.... | 3-62p | 18 40 5 " |
| " " " | " | " | " | " 21.... | 6-30p | 18 41 8 " |
| " " " | 50 26 0 | 104 36 0 | 1906 7 | " | " | 19 12 0 " |
| East end of Great Devil's portage..... | 55 40 0 | 104 47 8 | 1843 | Sept. 1.... | 9-27a | 24 48 5 " |
| " " " | " | " | " | " | " | " |
| " " " | " | " | " | " | " | " |
| " " " | " | " | " | " | " | " |
| West of Fort à la Corne. . . . | 53 09 7 | 104 50 3 | 1884 | May 26.... | 3-45p | 21 50 0 E. |
| 2½ miles below forks of Saskatchewan river..... | 53 13 0 | 104 51 6 | 1844 | Aug. 27.... | 4-44p | 24 45 0 " |
| " " " | " | " | " | " | " | " |
| " " " | " | " | 1859 | " | " | 22 30 0 E. |
| Trout Falls portage. | 55 42 9 | 104 58 8 | 1888 | Sept. 7.... | 3-30p | 21 48 7 " |
| " " " | " | " | " | " 7.... | 3-50p | 22 52 0 " |
| Black Bear Island lake..... | 55 42 5 | 105 35 5 | " | " 2.... | 9-15a | 21 14 0 " |
| " " " | " | " | " | " 2.. | 1-29p | 21 32 0 " |
| Pine portage..... | 55 43 0 | 106 00 0 | 1843 | " | " | " |
| " " " | " | " | " | " | " | " |
| Carlton House. | 52 50 8 | 106 32 0 | 1841 | Aug. 26.. | 9-00a | 22 55 6 E. |
| " " " | " | " | " | " | " | " |
| " " " | " | " | " | " | " | " |
| Knee lake..... | 55 50 8 | 106 33 4 | 1888 | Aug. 26.... | 9-30a | 27 19 6 E. |

* Local disturbance.

SESSIONAL PAPER No. 25a

VIII—Con.

RESULTS—Con.

AND ALBERTA—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Tempe- rature. | Observer. |
|-------------------|------------------------|---------|-------------------|------------------------|-----------------|------------------|-------------------|---------------|
| | 3-20 | | | | | | o | |
| June 26.... | to 4-15p | 78 11.4 | | | | | | W. F. King. |
| " 26.... | 4-45 | | | | | | | " |
| | to 5-25p | 78 05.7 | | | | | | " |
| July 5..... | 6-30 | 77 21.0 | | | | | | " |
| " 5..... | 5-45 | | | | | | | " |
| | to 6-20p | 77 25.5 | | | | | | " |
| June 30.... | 6-15 | | | | | | | " |
| | to 6-30p | 77 51.6 | | | | | | " |
| | 11-15 | | | | | | | " |
| June 29.... | to 12-00a | 77 53.2 | | | | | | " |
| | 3-00 | | | | | | | " |
| June 2.... | to 3-50p | 79 09.7 | June 2.... | 4-00 | | 6544 | 80 | Otto Klotz. |
| | 0-10 | | | 9-50 | | | | |
| Sept. 15.... | to 0-40p | 80 45.0 | Sept. 15.... | to 10-10a | | 6408 | 70 | Th. Fawcett. |
| " 15.... | 0-45 | | " 15.... | 10-10 | | 6408 | 70 | " |
| | to 1-14p | 80 45.1 | " 13.... | to 10-32a | | 6389 | 55 to 60 | " |
| " 13.... | 4-25 | | | 4-40 | | | | " |
| | to 4-37p | 80 33.4 | " 13.... | to 4-58p | | 6373 | 55 | " |
| " 13.... | 5-15 | | " 13.... | 5-00 | | 6366 | | J. H. Lefroy. |
| Aug. 31.... | to 5-30p | 80 35.3 | Aug. 31.... | to 5-13p | | 6925 | | " |
| | 3-30p | 80 16.4 | " 31.... | | | | | " |
| | 9-30 | | | 11-05 | | | | " |
| July 21.... | to 10-50a | 77 06.2 | July 21.... | to 12-00a | | 6401 | 76 | E. Deville. |
| " 21.... | 4-15 | | " 21.... | 5-15 | | 6403 | | " |
| | to 5-05a | 77 04.0 | " 21.... | to 6-15p | | | | " |
| | | 76 57.2 | | | 1427 | | | C. I. |
| Sept. 1.... | 10-00a | 80 30.9 | Sept. 1.... | | | 6516 | | J. H. Lefroy. |
| | | | " 1.... | | | 6514 | | " |
| | | | " 1.... | | | 6460 | | " |
| | 4-05 | | " 1.... | | | 6464 | | " |
| May 26.... | to 5-05p | 78 59.3 | May 26.... | 5-30 | | 6443 | 64 | Otto Klotz. |
| | | | | to 6-00p | | | | |
| Aug. 27.... | | 79 11.2 | Aug. 27.... | | | 6422 | | J. H. Lefroy. |
| | | | " 27.... | | | 6404 | | " |
| | | | " 27.... | | | 6434 | | " |
| | 4-02 | | | 4-24 | | | | H. Y. Hind. |
| Sept. 7.... | to 4-22p | 80 37.1 | Sept. 7.... | to 4-40p | | 6422 | 60 | Th. Fawcett. |
| " 7.... | 5-00 | | " 7.... | 4-42 | | 6407 | 60 | " |
| | to 5-30p | 80 38.1 | " 7.... | to 4-58p | | | | " |
| " 2.... | 10-35 | | " 2.... | 11-45 | | 6512 | 60 | " |
| | to 11-00a | 80 43.2 | " 2.... | to 12-00a | | | | " |
| " 2.... | 11-00 | | " 2.... | 0-02 | | 6480 | 60 | " |
| | to 11-30a | 80 37.1 | " 2.... | to 0-18p | | 6491 | | J. H. Lefroy. |
| " 3.... | 4-30p | 80 40.3 | " 3.... | | | 6463 | | " |
| | | | " 3.... | | | 6450 | | " |
| Aug. 26.... | | 78 30.2 | Aug. 26.... | | | 6350 | | " |
| " 26.... | | 78 31.2 | " 26.... | | | 6366 | | " |
| | 10-30 | | " 26.... | 11-00 | | 6339 | | " |
| Aug. 26.... | to 10-57a | 80 48.2 | " 26.... | to 11-17a | | 6505 | 70 | Th. Fawcett. |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC
SASKATCHEWAN

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---------------------------------------|-----------|------------|-------|----------------|------------------|--------------|
| Knee lake. | 55 50.8 | 106 33.4 | 1888 | Aug. 26... | 2-00p | 27 53.7 E. |
| Snake rapid. | 55 44.1 | 106 35.0 | 1843 | | | |
| " | " | " | " | | | |
| Near Elbow, South Saskatchewan river. | 51 04.8 | 106 37.0 | 1880 | July 17... | 8-00p | 21 21.0 E. |
| " | " | " | " | " 18... | 6-00p | 21 17.0 " |
| Near the N. W. end of Old Wives lake. | 50 28.9 | 106 46.7 | " | " 20 .. | 7-00p | 21 18.7 " |
| Narrow Rapids lake. | 55 56.5 | 107 22.1 | 1888 | Aug. 19... | 1-50p | 24 03.9 " |
| " | " | " | " | | | |
| *Saskatchewan, near Elbow. | 52 21.4 | 107 23.0 | 1844 | Aug. 24. . | 2-30p | 25 21.4 E. |
| Portage Sonnaute | 55 54.0 | 107 36.0 | 1843 | Sept. 7 .. | 4-13p | 26 43.4 " |
| " | " | " | " | | | |
| " | " | " | " | | | |
| Ile à la Crosse. | 55 25.6 | 107 37.0 | 1888 | Aug. 11.... | 3-00p | 25 02.9 E. |
| " | " | " | " | | | |
| South Saskatchewan river. | 50 39.6 | 107 47.9 | 1884 | | | |
| Fort à la Crosse. | 55 26.8 | 107 54.0 | 1843 | Sept. 9 .. | 8-26a | 24 57.5 E. |
| " | " | " | " | " 9 .. | 8-54a | 24 35.0 " |
| " | " | " | " | " 9.... | 5-30p | 25 11.7 " |
| " | " | " | " | | | |
| " | " | " | " | | | |
| " | " | " | " | | | |
| " | " | " | " | | | |
| " | " | " | " | | | |
| " | " | " | 1819 | February .. | | 22 15.8 E. |
| " | " | " | 1825 | June 27.... | | 23 19.3 " |
| Narrows of Buffalo lake | 55 37.9 | 108 13.5 | 1888 | Aug. 5.... | 0-50p | 25 15.9 " |
| " | " | " | " | | | |
| Battleford. | 52 42.7 | 108 18.8 | 1880 | | | |
| " | " | " | " | | | |
| " | " | " | 1884 | July 28 .. | 10-00a | 22 12.7 E. |
| " | " | " | " | " 28 .. | 3-00p | 21 57.2 " |
| " | " | " | " | " 28.... | 6-00p | 21 59.9 " |
| " | " | " | " | " 29.... | 7-40a | 22 15.4 " |
| " | " | " | " | " 29.... | 9-10a | 22 06.2 " |
| " | " | " | " | " 29.... | 0-35p | 21 58.2 " |
| *Willow hills | 53 00.1 | 108 30.0 | 1844 | Aug. 23.... | p.m. | 28 24.1 " |
| " | " | " | " | | | |
| Northern end of Buffalo lake. | 56 04.0 | 108 40.0 | 1843 | | | |
| " | " | " | " | | | |
| " | " | " | " | | | |
| Sidewood, on Cypress trail | 50 02.6 | 108 51.4 | 1880 | July 24.... | 7-00p | 22 00.0 E. |

* Local disturbance.

SESSIONAL PAPER No. 25a

VIII—Con.

RESULTS—Con

AND ALBERTA—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Tem- perature | Observer. |
|-------------------|------------------------|---------|-------------------|------------------------|-----------------|------------------|------------------|---------------|
| Aug. 26... | 11-20 to 11-43a | 80 45 8 | Aug. 26... | 11-48 to 12-06a | | 6529 | 65 | Th. Fawcett. |
| Sept. 4.... | 1-30p | 80 38 8 | Sept. 4.... | | | 6537 | | J. H. Lefroy. |
| | | | " 4.... | | | 6505 | | " |
| | | | " 4.... | | | 6477 | | " |
| July 18.... | 7-20 to 7-50p | 77 05 5 | | | | | | W. F. King. |
| " 18 .. | 6-50 to 7-30p | 77 02 3 | | | | | | " |
| " 20.... | 5-50 to 6-35p | 76 51 3 | | | | | | " |
| Aug. 19.... | 2-30 to 3-00p | 80 39 8 | Aug. 19.... | 3-00 to 3-30p | | 6419 | 76 | Th. Fawcett. |
| " 19 ... | 3-35 to 4-00p | 80 34 2 | " 19.... | 5-15 to 5-40p | | 6426 | 73 | " |
| " 24.... | | 78 16 6 | " 24.... | | | 6495 | | J. H. Lefroy. |
| Sept. 7.... | p. m. | 80 11 2 | Sept. 7.... | | | 6481 | | " |
| | | | " 7.... | | | 6482 | | " |
| | | | " 7.... | | | 6438 | | " |
| | | | " 7.... | | | 6499 | | " |
| Aug. 11.... | 5-45 to 6-35 | 79 56 1 | Aug. 11.... | 4-15 to 4-35p | | 6371 | 75 | Th. Fawcett. |
| " 11 .. | 4-00 to 5-30p | 79 58 1 | " 11.... | 6-40 to 7-04p | | 6371 | 66 | " |
| May 8 ... | 6-30 to 7-30 | 76 32 5 | May 8.... | 5-35 to 6-30p | | 6132 | 58 | Otto Klotz. |
| Sept. 9 ... | | 80 09 1 | Sept. 9.... | | | 6476 | | J. H. Lefroy. |
| " 9.... | | 80 10 5 | " 9.... | | | 6471 | | " |
| | | | " 9.... | | | 6454 | | " |
| | | | " 9.... | | | 6449 | | " |
| | | | " 9.... | | | 6442 | | " |
| | | | " 9.... | | | 6442 | | " |
| | | | " 9.... | | | 6440 | | " |
| | | | " 9.... | | | 6469 | | " |
| | | | " 9.... | | | 6442 | | " |
| | | | " 9.... | | | 6439 | | " |
| July 11.... | | 79 55 0 | | | | | | J. Franklin. |
| Aug. 5 ... | 1-40 to 2-06p | 80 11 9 | Aug. 5.... | 2-13 to 2-36p | | 6427 | 68 | Th. Fawcett. |
| " 5.... | 2-42 to 3-08p | 80 13 3 | " 5.... | 3-10 to 3-35p | | 6429 | 60 | " |
| Nov. 1.... | 9-45 to 10-10a | 77 52 3 | | | | | | W. F. King. |
| " 2.... | 11-15 to 11-40a | 77 46 4 | | | | | | " |
| | | | | | | | | E. Deville. |
| | | | | | | | | " |
| | | | | | | | | " |
| | | | | | | | | " |
| Aug. 23 ... | p.m. | 78 28 1 | Aug. 23.... | | | 6569 | | J. H. Lefroy. |
| | | | " 23.... | | | 6548 | | " |
| | | | " 23.... | | | 6585 | | " |
| Sept. 13. . | 7-00a | 89 37 0 | Sept. 13.... | | | 6472 | | " |
| | | | " 13.... | | | 6470 | | " |
| | | | " 13.... | | | 6457 | | " |
| | | | " 13.... | | | 6420 | | " |
| July 25.... | 1-20 to 1-55p | 75 50 1 | | | | | | W. F. King. |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

SASKATCHEWAN

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|--|-----------|------------|-------|----------------|------------------|--------------|
| River La Loche..... | 56 11.6 | 108 57.5 | 1888 | July 29... | 2-10p | 28 19.0 E. |
| " | " | " | " | " | " | " |
| La Loche lake..... | 56 26.6 | 109 12.8 | 1888 | July 22 .. | 2-10p | 25 49.0 E. |
| " | " | " | " | " | " | " |
| North end of Long portage.... | 56 14.7 | 109 18.0 | 1843 | Sept. 14.... | 9-35a | 28 40.6 E. |
| " | " | " | " | " 14.... | 9-43a | 28 27.5 " |
| " | " | " | " | " | " | " |
| Portage La Loche..... | 56 35.2 | 109 30.2 | 1888 | July 18.... | 10-00a | 26 37.3 E. |
| " | " | " | " | " | " | " |
| Great Methye portage..... | 56 35.0 | 109 37.0 | 1843 | Sept. 16.... | 8-38a | 26 15.0 E. |
| " | " | " | " | " 16.... | 9-30a | 26 59.7 " |
| " | " | " | " | " | " | " |
| Fort Pitt..... | 53 34.1 | 109 47.2 | 1844 | Aug. 22.... | 6-50a | 23 07.3 E. |
| " | " | " | " | " 22.... | 7-57a | 23 11.2 " |
| " | " | " | " | " | " | " |
| At the gap of Cypress hills.... | 49 37.7 | 109 51.4 | 1880 | July 31.... | 7-00p | 21 43.7 E. |
| Great Methye p'tge, N.W. end | 56 43.7 | 109 52.3 | 1820 | " | " | 25 02.5 " |
| " | " | " | 1843 | Sept. 17.... | 7-09a | 28 30.3 " |
| " | " | " | " | " 17.... | 7-22a | 28 25.0 " |
| " | " | " | " | " 17.... | 7-30a | 28 30.6 " |
| Clear Water river..... | 56 42.7 | 110 03.9 | 1888 | July 8 .. | 10-00a | 26 53.5 " |
| " | " | " | " | " | " | " |
| Land survey station..... | 51 05.0 | 110 15.0 | 1882 | " | " | " |
| Clear Water river..... | 56 39.4 | 110 46.6 | 1888 | July 1.... | 10-40a | 28 54.3 E. |
| " | " | " | " | " 1.... | 2-00p | 28 56.9 " |
| Two miles below mouth of Pembina river..... | 59 39.0 | 110 55.0 | 1843 | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Saskatchewan river near Moose Hill creek..... | 53 50.0 | 110 59.0 | 1844 | Aug. 21.... | 8-08a | 24 26.6 E. |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Fort McMurray..... | 56 43.9 | 111 13.6 | 1888 | June 23.... | 9-00a | 29 02.4 E. |
| " | " | " | " | " | " | " |
| Fort Chipewyan, L. Athabaska | 58 43.0 | 111 18.7 | 1843 | Sept. 23 ... | 3-50p | 28 09.1 E. |
| " | " | " | " | " 23.... | 3-59p | 27 08.4 " |
| " | " | " | " | Oct. 16 ... | " | 28 30.8 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | 1820 | March | " | 22 49.6 E. |
| " | " | " | 1825 | July 11.... | " | 25 29.0 " |
| " | " | " | 1843 | " | " | " |

SESSIONAL PAPER No. 25a

VIII—*Con.*RESULTS—*Con.*AND ALBERTA—*Con.*

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|---------------|
| July 29... | to 3-00 | 80 34 0 | July 29... | to 3-24 | | 6456 | 61 | Th. Fawcett. |
| " 29... | to 3-45 | | " 29... | to 3-43p | | 6435 | 59 | " |
| " 29... | to 4-20p | 80 33 1 | " 29... | to 4-25 | | 6409 | 76 | " |
| " 22... | to 2-45 | 80 31 9 | " 22... | to 4-32p | | 6352 | 86 | " |
| " 22... | to 3-20p | 80 35 5 | " 22... | to 5-02p | | 6389 | | J. H. Lefroy. |
| Sept. 14... | to 3-47 | 80 19 7 | " 22... | to 3-22 | | 6425 | | " |
| " 14... | to 4-25p | 80 19 7 | " 22... | to 3-45p | | 6401 | | " |
| " 14... | 10-15a | | " 14... | | | 6432 | | " |
| " 14... | | | " 14... | | | | | |
| July 18... | to 10-40 | 80 29 3 | July 18... | 11-14 | | 6397 | 88 | Th. Fawcett. |
| " 18... | to 11-10a | 80 28 3 | " 18... | to 11-35a | | 6417 | 81 | " |
| Sept. 16... | 11-45a | | " 18... | to 0-15 | | 6444 | | J. H. Lefroy. |
| " 16... | to 0-13p | 80 36 4 | " 16... | to 0-40p | | 6457 | | " |
| " 16... | 9-00a | | " 16... | | | 6426 | | " |
| " 16... | | | " 16... | | | 6467 | | " |
| Aug. 22... | a. m. | 78 43 0 | Aug. 22... | | | 6533 | | " |
| " 22... | " | 78 39 1 | " 22... | | | 6520 | | " |
| " 22... | | | " 22... | | | 6526 | | " |
| July 28... | to 0-15 | 75 20 4 | " 22... | | | | | W. F. King. |
| Sept. 17... | to 0-45p | 80 38 3 | " 22... | | | | | Franklin. |
| " 17... | 6-00a | | " 22... | | | | | J. H. Lefroy. |
| " 17... | | | " 22... | | | | | " |
| July 8... | 11-15 | 80 27 4 | July 8... | 11-50a | | 6377 | 76 | Th. Fawcett. |
| " 8... | to 11-45a | 80 25 5 | " 8... | to 0-15p | | 6425 | 65 | " |
| " 8... | 0 20 | 76 14 1 | " 8... | to 0-55 | | | | Wm. Ogilvie. |
| " 15... | to 0 50p | 80 09 1 | " 8... | to 1-20p | | 6419 | 66 | Th. Fawcett. |
| " 1... | 11-10 | 80 09 1 | July 1... | 11-40 | | 6460 | 68 | " |
| " 1... | to 11-40a | 80 12 1 | " 1... | to 12-00a | | | | J. H. Lefroy. |
| " 1... | 3-40 | | " 1... | 4-04 | | | | " |
| Sept. 19... | to 4-00p | 80 35 2 | " 1... | to 4-50p | | 6456 | | " |
| " 19... | 8 30a | | Sept. 19... | | | 6414 | | " |
| " 19... | | | " 19... | | | 6364 | | " |
| " 19... | | | " 19... | | | 6419 | | " |
| Aug. 21... | | 78 33 5 | Aug. 21... | | | 6410 | | " |
| " 21... | | | " 21... | | | 6350 | | " |
| " 21... | | | " 21... | | | 6391 | | " |
| June 23... | 9-30 | 80 07 8 | " 21... | | | | | " |
| " 23... | to 10-00a | 80 07 8 | June 23... | 10-04 | | 6334 | 57 | Th. Fawcett. |
| " 23... | 10-40 | 80 09 8 | " 23... | to 10-35a | | 6371 | 59 | " |
| Sept. 30... | to 11-04a | 81 37 7 | " 23... | 11-04 | | 6374 | | J. H. Lefroy. |
| " 30... | 9-00a | 81 37 5 | Sept. 25... | to 11-30a | | 6413 | | " |
| " 30... | 11-00a | | " 25... | | | 6383 | | " |
| " 30... | | | Oct. 9... | | | 6449 | | " |
| " 30... | | | Sept. 30... | | | 6446 | | " |
| " 30... | | | Oct. 6... | | | 6456 | | " |
| " 30... | | | " 10... | | | | | J. Franklin. |
| July 24... | | 81 26 1 | " 10... | | | | | " |
| " 24... | | | Oct. 13... | | | 6419 | | J. H. Lefroy. |

SESSIONAL PAPER No. 25a

VIII—*Con.*RESULTS—*Con.*AND ALBERTA—*Con.*

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------|---------|----------------|------------------|--------------|---------------|-------------|---------------|
| | | | Oct. 13. | | | 6399 | | J. H. Lefroy. |
| | | | " 13. | | | 6424 | | " |
| | | | " 13. | | | 6418 | | " |
| | | | " 13. | | | 6411 | | " |
| | | | " 14. | | | 6386 | | " |
| | | | " 14. | | | 6453 | | " |
| | | | " 14. | | | 6425 | | " |
| | | | Mar. 1. | | | 6384 | | " |
| | | | " 1. | | | 6363 | | " |
| | | | " 1. | | | 6331 | | " |
| | | | " 1. | | | 6368 | | " |
| Feb. 27. | 1-04p | 81 35.4 | July 2. | | | 6431 | | " |
| | | | " 2. | | | 6433 | | " |
| | | | " 2. | | | 6426 | | " |
| Sept. 17. | | 81 26.6 | | | | | | H. P. Dawson. |
| | 1-50 | | | 2-25 | | | | |
| Nov. 22. | to 2-21p | 81 22.2 | Nov. 22. | to 2-45p | | 6335 | 17.5 | Wm. Ogilvie. |
| | 3-06 | | | 2-48 | | | | |
| " 22. | to 3-24p | 81 21.4 | " 22. | to 3-04p | | 6306 | 17.5 | " |
| | 1-45 | | | 2 05 | | | | |
| " 23. | to 2-07p | 81 23.3 | " 23. | to 2 20p | | 6348 | 18. | " |
| | 3-05 | | | 2 40 | | | | |
| " 23. | to 3-25p | 81 21.7 | " 23. | to 3-01p | | 6355 | 16. | " |
| | 2-45 | | | | | | | |
| Oct. 17. | to 3-05p | 77 56.8 | | | | | | W. F. King. |
| Sept. 21. | 4-00p | 81 30.6 | Sept. 21. | | | 6402 | | J. H. Lefroy. |
| | | | " 21. | | | 6475 | | " |
| | | | " 21. | | | 6438 | | " |
| | | | " 21. | | | 6493 | | " |
| Sept. 20. | 2-30p | 81 16.8 | Sept. 20. | | | 6739 | | " |
| | | | " 20. | | | 6615 | | " |
| | | | " 20. | | | 6597 | | " |
| | | | " 20. | | | 6631 | | " |
| Aug. 6. | | 76 16.5 | | | | | | Wm. Ogilvie. |
| " 6. | | 76 09.7 | | | | | | " |
| June 27. | | 82 26.8 | | | | | | J. H. Lefroy. |
| July 5. | | 81 46.1 | | | | | | " |
| Aug. 20. | | 78 05.2 | Aug. 20. | | | 6330 | | " |
| | | | " 20. | | | 6311 | | " |
| | | | " 20. | | | 6316 | | " |
| July 7. | | 81 36.9 | | | | | | " |
| | 3-50 | | | | | | | |
| Aug. 17. | to 4-20p | 74 44.8 | | | | | | W. F. King. |
| | 5-25 | | | | | | | |
| " 17. | to 5-40p | 74 47.9 | | | | | | " |
| | | | | | | | | " |
| | 4-26 | | | 5-07 | | | | |
| May 27. | to 5-05p | 78 08.3 | May 27. | to 5-40p | | 6351 | 70 | Th. Fawcett. |
| | 7-35 | | | 7-40 | | | | |
| " 28. | to 8-28a | 78 07.2 | " 28. | to 8-28a | | 6415 | 51 | " |
| Aug. 17. | | 77 53.4 | Aug. 17. | | | 6476 | | J. H. Lefroy. |
| " 17. | | 77 55.1 | " 17. | | | 6418 | | " |
| | | | " 17. | | | 6474 | | " |
| | | | " 17. | | | 6499 | | " |
| | | | " 17. | | | 6468 | | " |
| | 4-40 | | | | | | | |
| Oct. 6. | to 5-00p | 77 31.6 | | | | | | W. F. King. |
| | 10-20 | | | | | | | |
| " 7. | to 10-40a | 77 29.4 | | | | | | " |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

C. I.—Carnegie Institution.

SASKATCHEWAN

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---|-----------|------------|--------|----------------|------------------|--------------|
| Fort Edmonton | 53 32.0 | 113 30.1 | 1888 | May 17 | 1-30p | 25 28.7 E |
| " | " | " | " | " | " | " |
| At north branch, Pipestone creek | 53 04.3 | 113 35.5 | 1880 | Sept. 25... | 6-00p | 25 14.4 " |
| Mosquito creek | 50 22.4 | 113 48.8 | " | Aug. 20 | 7-00p | 22 03.0 " |
| " | " | " | " | " | " | " |
| Forks of the Athabaska | 55 13.0 | 113 53.2 | 1844 | Aug. 7. | 4-44p | 26 28.0 " |
| Fourth base on 5 th meridian | 50 02.9 | 114 00.0 | 1887 | July 19..... | 1-50p | 23 53.7 " |
| Land survey station | 54 21.3 | 114 00.0 | 1883 | " | " | " |
| Athabaska river | 54 43.0 | 114 00.2 | 1844 | Aug. 9..... | 9-10a | 26 29.1 " |
| Crossing of Pembina river | 54 03.2 | 114 00.2 | " | " 14..... | 9-42a | 22 23.0 " |
| Mouth of Lesser Slave lake | 55 29.0 | 114 03.5 | 1888 | June 4..... | noon. | 27 22.5 " |
| " | " | " | " | " 4. | 3-15p | 27 25.3 " |
| Land survey station | 55 10.0 | 114 03.5 | 1883 | May 9 | " | 27 45.4 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Near Fort Calgary | 51 03.0 | 114 04.6 | 1880 | " | " | " |
| Poplar island | 58 39.0 | 114 10.7 | 1844 | July 9..... | 9-30a | 26 29.8 " |
| Morleyville, Rocky Mt. | 51 10.5 | 114 18.5 | 1880 | " | " | " |
| " | " | " | " | " | " | " |
| Fort Assiniboine | 54 21.7 | 114 28.4 | 1844 | Aug. 11..... | 7-02a | 24 39.0 " |
| " | " | " | " | " | " | " |
| Falls of the Peace river | 58 24.2 | 114 51.1 | " | July 10..... | 10-38a | 30 22.0 " |
| Swan point, Lesser Slave lake | 55 26.0 | 115 03.1 | " | Aug. 6..... | 10-00a | 26 19.0 " |
| Sulphur mountain | 51 09.0 | 115 34.0 | 1907-5 | " | " | 25 53.5 " |
| Banff | " | " | " | " | " | 25 59.3 " |
| Tunnel mountain | 51 11.0 | " | " | " | " | 25 57.4 " |
| Banff (C.I.S.) | 51 10.0 | 115 37.0 | 1908 | July 22-24.. | " | 26 5.6 " |
| Fort Vermilion | 58 24.5 | 115 58.6 | 1844 | July 11..... | 6-31p | 32 40.0 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Fort of Lesser Slave lake | 58 32.6 | 116 00.0 | " | Aug. 3. | 5-37p | 26 52.5 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Land survey station | 55 32.5 | 116 08.6 | 1883 | " | " | " |
| On Peace river. | 57 19.0 | 117 01.7 | 1844 | July 17. | 8-39a | 28 53.0 " |
| Opposite River Cadotte | 56 47.0 | 117 01.7 | " | " 19..... | 9-17a | 27 03.0 " |
| Island opposite Baril river | 57 57.0 | 117 04.7 | " | " 15..... | 8-22a | 29 56.0 " |
| Land survey station | 56 08.0 | 117 50.6 | 1883 | " | " | " |
| " | " | " | " | " | " | " |
| Fort Dunvegan | 55 55.6 | 118 28.5 | 1844 | July 23.... | 10-05a | 27 09.0 " |
| " | " | " | " | " 25.... | 5-49p | 27 24.0 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |

SESSIONAL PAPER No. 25a

VIII—Con.

RESULTS—Con.

AND ALBERTA—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|------------------------|---------|----------------|------------------|--------------|---------------|-------------|---------------|
| May 17..... | 1-50 to 3-05p | 77 30.4 | May 17... | 4-11 to 5-00p | | 6391 | | Th. Fawcett. |
| " 17..... | 3-21 to 3-53p | 77 30.9 | " | | | | | " |
| Sept. 26... | 6-30 to 6-50a | 77 03.2 | | | | | | W. F. King. |
| Aug. 20... | 5-45 to 6-10p | 74 40.1 | | | | | | " |
| " 21..... | 6-15 to 6-30a | 74 48.2 | | | | | | " |
| Aug. 7..... | | 78 55.2 | | | | | | J. H. Lefroy. |
| July 19..... | | 74 37.5 | | | | | | J. S. Dennis. |
| Jan. 1..... | | 77 58.1 | | | | | | Wm. Ogilvie. |
| Aug. 9..... | | 78 34.1 | | | | | | J. H. Lefroy. |
| " 14..... | | 77 54.0 | | | | | | " |
| June 4..... | 1-00 to 1-30p | 78 31.7 | June 4..... | 1-38 to 2-05p | | 6308 | | Th. Fawcett. |
| " 4..... | 1-38 to 2-40p | 78 33.3 | " 4..... | 2-07 to 2-40p | | 6323 | | Wm. Ogilvie. |
| May 10..... | | 78 24.1 | | | | | | " |
| " 11..... | | 78 28.2 | | | | | | " |
| " 11..... | | 78 29.9 | | | | | | " |
| Sept. 11..... | 1-00 to 1-20p | 75 23.4 | | | | | | W. F. King. |
| July 9..... | | 81 04.8 | | | | | | J. H. Lefroy. |
| Sept. 16..... | 0-25 to 0-45p | 75 14.3 | | | | | | W. F. King. |
| " 16..... | 3-00 to 3-15p | 75 19.7 | | | | | | " |
| Aug. 11..... | | 78 16.9 | | | | | | J. H. Lefroy. |
| " 11..... | | 78 13.5 | | | | | | " |
| July 10..... | | 80 50.8 | | | | | | " |
| Aug. 6..... | | 78 29.9 | | | | | | " |
| " | | 74 54.0 | | | 1590 | | | C.I. |
| " | | 74 56.3 | | | 1593 | | | C.I. |
| " | | 74 57.6 | | | 1593 | | | C.I. |
| July 23, 24.. | | 74 58.1 | July 22-24.. | | 15955 | | | C. A. French. |
| July 11..... | | 80 48.4 | July 11..... | | 6505 | | | J. H. Lefroy. |
| " 11..... | | 80 47.6 | " 11..... | | 6409 | | | " |
| " | | | " 11..... | | 6472 | | | " |
| " | | | " 11..... | | 6515 | | | " |
| " | | | " 11..... | | 6463 | | | " |
| Aug. 3..... | | 78 36.2 | Aug. 5..... | | 6422 | | | " |
| " 3..... | | 78 41.8 | " 5..... | | 6397 | | | " |
| " | | | " 5..... | | 6369 | | | " |
| Oct. 3..... | (78 18.1) (78 12.4) | | | | | | | Wm. Ogilvie. |
| July 17..... | | 79 27.0 | | | | | | J. H. Lefroy. |
| " 19..... | | 79 20.7 | | | | | | " |
| " 15..... | | 80 00.7 | | | | | | " |
| Sept. 22..... | | 78 14.3 | | | | | | Wm. Ogilvie. |
| " 22..... | | 78 20.2 | | | | | | " |
| July 22..... | | 78 45.7 | July 23..... | | 6477 | | | J. H. Lefroy. |
| " 22..... | | 78 46.8 | " 23..... | | 6439 | | | " |
| " | | | " 23..... | | 6445 | | | " |
| " | | | " 23..... | | 6452 | | | " |
| " | | | " 23..... | | 6452 | | | " |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC

C. I. — Carnegie Institution.

BRITISH

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---|-----------|------------|--------|----------------------|------------------|--------------|
| Akamina station..... | 49 01'0 | 114 04'0 | 1861 | Aug. 2.... | ..... | 23 12'0 E |
| *Wigwam river section..... | 49 00'0 | 114 45'0 | " | July 15, Aug. 14.... | ..... | 23 52'0 " |
| Camp No. 11..... | 49 07'0 | 115 16'0 | " | ..... | ..... | ..... |
| Joseph's prairie, Camp No. 14. | 49 31'0 | 115 35'0 | " | ..... | ..... | ..... |
| Stephen, Rocky mountains ... | 51 27'0 | 116 17'7 | 1886 | May 14.... | 4-00p | 23 55'0 " |
| Near Leancoil, along C.P.R. | 51 13'8 | 116 37'9 | " | " 28... | 4-45p | 23 33'0 " |
| Between Palliser and Golden, | 51 17'9 | 116 51'7 | " | June 4.... | 11-00a | 25 40'0 " |
| C.P.R..... | 51 18'0 | 116 57'0 | 1908 | July 27-30.... | ..... | 26 03'5 |
| Golden..... | " | " | " | ..... | ..... | ..... |
| One mile north of Golden.... | 51 18'8 | 116 58'5 | 1886 | June 9.... | 5-54p | 25 37'0 E |
| Keefe and Clarke siding ... | 51 30'9 | 117 20'4 | " | " 18 .. | 9-21a | 26 34'0 " |
| Glacier..... | 51 16'0 | 117 28'0 | 1907-8 | ..... | ..... | 25 57'1 " |
| Near Rogers pass, along C.P.R. | 51 17'6 | 117 31'0 | 1886 | June 30.... | 2-45p | 25 27'5 " |
| Near Revelstoke, along C.P.R. | 51 00'1 | 118 11'9 | " | Aug. 15.... | 4-23p | 27 17'5 " |
| Revelstoke | 51 00'0 | 118 12'0 | 1908 | Aug. 3, 4, 5.... | ..... | 25 48'6 |
| " | " | " | " | | | |
| Inchwointum station | 49 00'0 | 118 28'0 | 1860 | Nov. 13.... | ..... | 20 17'0 |
| Sicamous | 50 50'0 | 118 59'0 | 1908 | Aug. 6-10.... | ..... | 25 52'8 |
| Sicamous narrows..... | 50 49'7 | 118 59'6 | 1885 | Oct. 21.... | 11-20a | 24 46'2 " |
| " | " | " | " | | | |
| 120 yds. west of station 1569 of traverse. | 50 44'7 | 119 14'5 | " | " 4 .. | 4-50p | 24 37'5 " |
| " | " | " | " | | | |
| Lake Shuswap, Blind bay ... | 50 51'0 | 119 19'5 | " | ..... | ..... | ..... |
| " | " | " | " | | | |
| Southwest end of Salmon Arm, | 50 45'9 | 119 19'9 | " | Sept. 25.... | 5-10p | 24 55'9 E |
| Lake Shuswap..... | " | " | " | " 27.... | 5-15p | 24 46'9 " |
| " | " | " | " | | | |
| " | " | " | " | | | |
| Little Shuswap..... | 50 48'6 | 119 41'2 | " | Sept. 13.. | 4-45p | 25 07'5 E |
| " | " | " | " | | | |
| Ashtnolaon station..... | 49 00'0 | 120 00'0 | 1860 | Aug. 17, 18.... | ..... | 22 44'0 " |
| On Ashtnolaon river..... | 49 10'0 | 120 00'0 | " | July ..... | ..... | 22 10'0 " |
| 350 yds. south of station 1289 traverse..... | 50 38'9 | 120 06'9 | 1885 | Sept. 6. . | 4-00p | 24 59'4 " |
| " | " | " | " | | | |

* Local disturbance.

SESSIONAL PAPER No. 25a

IX.

RESULTS.

COLUMBIA.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|-------------------|--------------------|---------|-------------------|--------------------|--------------|---------------|-------------|---------------|
| Aug. 2 | | 73 42.7 | Aug. 2 | | | 6265 | | R. W. Haig. |
| July 15, Aug. 14. | | 73 30.8 | July 15, Aug. 14. | | | 6223 | | do |
| | | 73 37.8 | | | | 6226 | | J. L. Harris. |
| | | 73 50.4 | | | | | | do |
| May 14. | 4 45 to 5-25p | 75 04.6 | May 14. | 5-30 to 5-55p | | 6177 | 47 | O. Klotz. |
| " 28 | 5-00 to 5-35 | 74 49.5 | " 28. | 5-43 to 6-10p | | 6174 | 59 | do |
| June 4. | 11-30 to 0-05p | 74 54.2 | June 4. | 0-07 to 0-50p | | 6168 | 85 | do |
| July 27-29. | | 74 42.8 | July 27-29. | | 16160 | | | C. A. French. |
| " 28 | | 74 40.1 | | | 16142 | | | do |
| June 9 | 4-11 to 4-36p | 74 50.4 | June 9. | 4-40 to 5-14p | | 6171 | 72 | O. Klotz. |
| June 18. | 9-40 to 10-03a | 74 52.5 | June 18. | | | 6166 | 59 | do |
| | | 74 29.9 | | | 1625 | | | C. I. |
| June 30. | 3-01 to 3-22p | 74 41.6 | June 30. | 3-25 to 3-44p | | 6167 | 61 | O. Klotz. |
| Aug. 15 | 4-52 to 5-36p | 74 26.4 | Aug. 15. | 5-50 to 6-44p | | 6144 | 70 | do |
| Aug. 1, 3, 4. | | 74 16.1 | Aug. 1, 3, 4. | | 16501 | | | C. A. French. |
| " 5. | | 74 16.6 | " 5. | | 16458 | | | do |
| Nov. 13 | | 72 48.8 | Nov. 13. | | | 6119 | | R. W. Haig. |
| Aug. 6, 7, 8. | | 73 51.8 | Aug. 6, 9. | | 16775 | | | C. A. French. |
| Oct. 21. | 9-45 to 10-02a | 74 06.1 | Oct. 21. | 10-08 to 10-27a | | 6141 | 44 | W. Ogilvie. |
| " 21. | 10-51 to 11-10a | 74 07.8 | " 21. | 10-33 to 10-46a | | 6123 | 45 | do |
| " 4. | 3-08 to 3-27p | 73 58.9 | " 4. | 3-32 to 3-48p | | 6139 | 65 | do |
| " 4. | 4-18 to 4-40p | 73 58.2 | " 4. | 3-54 to 4-11p | | 6146 | 62 | do |
| Sept. 20. | 2-55 to 3-20p | 73 58.0 | Sept. 20. | 3-25 to 3-45p | | 6169 | 66 | do |
| " 20. | 4-20 to 4-45p | 73 59.0 | " 20. | 3-50 to 4-13p | | 6164 | 65 | do |
| " 25. | 3-25 to 3-41p | 73 59.0 | " 25. | 3-45 to 4-06p | | 6164 | 62 | do |
| " 25. | 4-33 to 4-59p | 73 57.1 | " 25. | 4-10 to 4-27p | | 6143 | 62 | do |
| " 27. | 2-48 to 3-11p | 73 58.8 | " 27. | 3-18 to 3-34p | | 6139 | 59 | do |
| " 27. | 4-10 to 4-30p | 74 00.4 | " 27. | 3-45 to 4-04p | | 6144 | 59 | do |
| Sept. 13. | 2-30 to 2-50p | 73 55.2 | " 13. | 2-55 to 3-20p | | 6143 | 64 | do |
| " 13. | 4-05 to 4-25 | 73 48.0 | " 13. | 3-30 to 3-56p | | 6170 | 63 | do |
| Aug. 17, 18. | | 72 27.0 | Aug. 17, 18. | | | 6142 | | R. W. Haig. |
| July | | 72 37.0 | July | | | 6098 | | do |
| Sept. 6. | 2-15 to 2-35p | 73 41.4 | Sept. 6. | 2-40 to 3-03p | | 6098 | 84 | W. Ogilvie. |
| " 6. | 3-30 to 3-32p | 73 41.0 | " 6. | 3-08 to 3-23p | | 6096 | 84 | do |

9-10 EDWARD VII., A. 1913

TABLE

MAGNETIC

C. I.—Carnegie Institution.

BRITISH

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|------------------------------|-----------|------------|--------|------------------------------|------------------|--------------|
| | ° ' " | ° ' " | | | | ° ' " |
| Thompson river..... | 50 41.0 | 120 11.0 | 1833 | | | |
| Kamloops | 50 39.9 | 120 20.2 | 1885 | Sept. 2.... | 3-50p | 24 20.5 E |
| " | " | " | " | " 3.... | 5-30p | 23 35.5 " |
| " | " | " | " | | | |
| Nicola..... | 50 09.0 | 120 40.0 | 1908 | Sept. 19-21. | | 25 03.0 |
| " | " | " | " | | | |
| Van Horne. | 50 44.4 | 120 50.3 | 1885 | | | |
| St. Cloud..... | 50 45.9 | 121 07.8 | " | Aug. 16 ... | 4-55p | 23 51.5 E |
| Ashcroft (C. I. S.).... | 50 44.0 | 121 17.0 | 1908 | Sept. 14, 15. | | 27 46.9 E |
| " | " | " | " | | | |
| " | " | " | 1907-7 | | | 27 36.1 E |
| Near Black canyon.. | 50 39.6 | 121 17.9 | 1885 | Aug. 9.... | 4-55p | 27 22.5 " |
| " | " | " | " | | | |
| Spence's bridge..... | 50 24.3 | 121 20.7 | " | " 2.... | Noon | 23 43.8 E |
| " | 50 25.0 | 121 21.0 | 1908 | Sept. 17, 18. | | 26 39.4 |
| " | " | " | " | | | |
| Chilukweyuk | 49 02.0 | 121 23.0 | 1859 | | | |
| Chilukweyuk camp. | 49 06.0 | 121 23.0 | " | | | |
| Bridge creek (100-mile).... | 51 39.0 | 121 27.0 | 1908 | Sept. 8, 9 ... | | 26 47.4 |
| North Bend | 49 52.0 | 121 27.0 | " | " 23-25.. | | 25 48.0 |
| " | " | " | " | | | |
| Barkerville..... | 53 04.0 | 121 30.0 | 1908 | Aug. 22-24.. | | 28 07.3 E. |
| " | " | " | " | | | |
| Salmon river..... | 49 58.3 | 121 30.6 | 1885 | July 12. ... | 5-00p | 24 59.0 " |
| " | " | " | " | | | |
| Cisco station.. | 50 07.4 | 121 34.4 | " | | | |
| " | " | " | " | | | |
| Clinton | 51 06.0 | 121 35.0 | 1908 | Aug. 13-16.. | | 26 26.4 |
| " | " | " | " | | | |
| Agassiz..... | 49 15.0 | 121 45.0 | " | Oct. 1, 2.... | | 25 23.6 |
| " | " | " | " | | | |
| Williams lake (150 mile).... | 52 06.0 | 121 56.0 | " | Sept. 3-5.... | | 28 52.8 E. |
| " | " | " | " | | | |
| Harrison river..... | 49 13.4 | 121 56.0 | 1885 | June 14 ... | 6-20p | 22 21.3 " |
| " | " | " | " | " 14.... | 6-25p | 22 25.4 " |
| Schweltza lake station..... | 49 02.0 | 122 00.0 | 1859 | July 4, 5.... | | 21 37.0 " |
| Sumas prairie | 49 01.0 | 122 12.0 | 1858 | { Oct. 4, 5 } { Nov. 10 } | | 21 30.0 " |

SESSIONAL PAPER No. 25a

IX—*Con.*RESULTS—*Con.*COLUMBIA—*Con.*

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|--------------------|---------|----------------|--------------------|--------------|---------------|-------------|---------------|
| | | ° | | | | | ° | |
| April | | 73 43.0 | | | | 5939 | | D. Douglas. |
| Sept. 2.... | 2-00 to 2-23p | 73 35.8 | Sept. 2.... | 2-27 to 2-42p | | 6071 | 75 | Wm. Ogilvie |
| " 2.... | 3-25 to 3-48p | 73 34.2 | " 2.... | 2-53 to 3-18p | | 6065 | 75 | do |
| " 3.... | 3-48 to 4-10p | 73 37.5 | " 3.... | 4-15 to 4-30p | | 6054 | 79 | do |
| " 3.... | 5-00 to 5-20p | 73 39.0 | " 3.... | 4-35 to 4-54p | | 6085 | 79 | do |
| Sept. 19, 20. | | 72 54.0 | Sept. 19, 20. | | 1755 | | | C. A. French. |
| " 21.... | | 72 53.4 | " 21.... | | 1753 | | | do |
| Aug. 23.... | 2-50 to 3-15p | 73 28.0 | Aug. 23.... | 3-20 to 3-43p | | 6037 | 71 | Wm. Ogilvie. |
| Aug. 16.... | 2-45 to 3-10p | 74 00.8 | Aug. 16.... | 3-18 to 3-40p | | 6166 | 94 | do |
| " 16.... | 4-22 to 4-47p | 74 02.6 | " 16.... | 3-50 to 4-10p | | 6157 | 96 | do |
| Sept. 11, 12. | | | | | | | | |
| " 14.... | | 73 26.1 | Sept. 14, 15. | | 1722 | | | C. A. French. |
| " 12.... | | 73 26.8 | " 12.... | | 1721 | | | do |
| | | 73 22.2 | | | 1725 | | | C. I. |
| Aug. 9.... | 2-48 to 3-06p | 73 37.5 | Aug. 9.... | 3-10 to 3-32p | | 6123 | 88 | Wm. Ogilvie. |
| " 9.... | 4-08 to 4-38 | 73 40.3 | " 9.... | 3-42 to 4-02p | | 6111 | 88 | do |
| " 2.... | 9-45 to 10-20a | 73 26.8 | " 2.... | 10-25 to 10 55a | | 6048 | 85 | do |
| " 2.... | 11-47 to 12-17a | | " 2.... | 11-05 to 11-35a | | 6072 | 85 | do |
| Sept. 17.... | | 72 27.2 | Sept. 16, 17. | | 1737 | | | C. A. French. |
| " 18.... | | 72 57.6 | " 18.... | | 1741 | | | do |
| " 7.... | | 72 31.6 | Sept. 7.... | | 6077 | | | R. W. Haig. |
| | | 72 22.2 | | | 6125 | | | J. S. Harris. |
| Sept. 8, 9.... | | 73 35.1 | Sept. 8, 9.... | | 1717 | | | C. A. French. |
| " 23-25.... | | 72 32.1 | Sept. 24, 25. | | 1797 | | | do |
| " 26.... | | 72 31.2 | | | 1795 | | | do |
| Aug. 22, 23. | | 74 58.0 | Aug. 22, 23. | | 1571 | | | do |
| " 21.... | | 74 57.6 | " 21.... | | 1569 | | | do |
| July 12.... | 3-20 to 3-48p | 72 39.4 | July 12.... | 3-50 to 4-15p | | 6063 | 85 | W. Ogilvie. |
| " 12.... | 5-18 to 5-38p | 72 40.7 | " 12.... | 4-22 to 4-41p | | 6052 | 82 | do |
| " 19.... | 1-50 to 2-16p | 72 44.7 | " 19.... | 2-20 to 2-44p | | 6066 | 84 | do |
| " 19.... | 3-16 to 3-40p | 72 41.1 | " 19.... | 2-50 to 3-10p | | 6067 | 80 | do |
| Aug. 14, 15. | | 73 27.6 | Aug. 14, 15. | | 1704 | | | C. A. French. |
| " 13.... | | 73 25.1 | " 13.... | | 1722 | | | do |
| { Sept. 28 } | | 71 34.9 | Oct. 1, 2.... | | 1892 | | | do |
| { Oct. 1, 2 } | | | | | | | | do |
| Sept. 28.... | | 71 36.1 | Sept. 28.... | | 1890 | | | do |
| Sept. 3, 5.... | | 74 12.3 | " 3, 5.... | | 1652 | | | do |
| " 5.... | | 74 12.4 | " 5.... | | 1651 | | | do |
| June 14.... | 4-00 to 4-30p | 72 28.3 | June 14.... | 4-35 to 5-00p | | 5994 | 75 | W. Ogilvie. |
| " 14.... | 5-33 to 5-54p | 72 28.0 | " 14.... | 5-05 to 5-25p | | 6011 | 73 | do |
| July 4, 5.... | | 72 04.0 | July 4, 5.... | | 6125 | | | R. W. Haig. |
| { Oct. 4, 5 } | | | { Oct. 4, 5 } | | | | | do |
| { Nov. 10 } | | 72 22.0 | { Nov. 10 } | | 6163 | | | do |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETICC. I.—Carnegie Institution.
C. S.—Coast Survey.

BRITISH

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|-----------------------------------|-----------|------------|--------|----------------------------|------------------|--------------|
| Alexandria | 52 35 0 | 122 28 0 | 1908 | { Aug. 30 } { Sept. 1 } | | 28 16 2 |
| Fort Alexandria | 52 33 0 | 122 29 0 | 1833 | | | |
| Quesnel | 52 59 0 | 122 32 0 | 1908 | Aug. 26-28 | | 28 19 0 |
| Port Hammond | 49 12 1 | 122 38 0 | 1885 | May 26 | 6-38p | 22 46 2 E. |
| Camp Semiamu | 49 01 0 | 122 46 0 | 1857 | | | |
| Station Semiamu | 49 00 7 | 122 46 2 | 1857 | | | |
| Port Moody | 49 17 0 | 122 52 6 | 1885 | June 3 | 4-45p | 22 45 8 E. |
| New Westminster | 49 13 0 | 122 53 0 | 1862 | " 3 | 4-55p | 22 46 3 " |
| Vancouver | 49 18 0 | 123 07 0 | 1898 4 | | | 24 30 0 E. |
| Vancouver (Brockton Pt.) .. | 49 18 0 | 123 07 0 | 1908 | Oct. 5-8 | | 25 23 3 |
| Burrard inlet | 49 16 0 | 123 10 0 | 1859 | | | |
| Victoria (C. I. station) | 48 25 0 | 123 21 0 | 1908 | Oct. 13, 14 | | 24 34 0 |
| " | 48 25 0 | 123 21 0 | 1907 7 | | | 24 15 2 E. |
| " | 48 26 0 | 123 25 0 | 1858 | | | |
| " | 48 25 8 | 123 22 2 | 1880 | | | |
| Victoria, Laurel point | 48 25 4 | 123 22 5 | 1862 | | | |
| Esquimalt | 48 25 0 | 123 26 0 | 1881 8 | | | 22 55 6 " |
| " | 48 26 0 | 123 27 0 | 1859 | | | |
| " | " | " | 1862 | | | |
| " | " | 123 28 0 | 1892 7 | | | |
| Nanaimo (Jesse island) | 49 13 0 | 123 52 0 | 1898 3 | Oct. 17, 18 | | 23 42 9 E. |
| Departure bay, Vancouver I. .. | 49 12 6 | 123 57 0 | 1881 | Oct. 7 | | 23 55 6 E. |
| " | 49 12 6 | 123 58 5 | 1880 | | | |
| Nanaimo | 49 10 0 | 124 00 0 | 1862 | | | |
| Stuart lake | 54 27 0 | 124 20 0 | 1833 | | | |
| Fraser lake | 54 03 0 | 124 40 0 | 1833 | | | |
| Bayne sound (Maple spit) | 49 28 0 | 124 45 0 | 1898 4 | | | 24 25 7 E. |
| " (Beak point) | 49 36 0 | 124 51 0 | 1898 6 | | | 24 14 1 " |
| Union | 49 36 0 | 124 54 0 | 1900 8 | | | 25 55 6 " |
| Union (1) | 49 36 0 | 124 54 0 | 1904 3 | | | 26 05 6 " |
| Union (2) | " | " | 1906 5 | | | 26 00 9 E. |
| Waddington harbour | 50 54 0 | 124 49 5 | 1881 | July 30 | | 26 17 4 " |
| Henry bay, Vancouver island .. | 49 36 0 | 124 51 0 | 1860 | | | 25 22 0 " |
| Hecate bay, | 49 15 0 | 125 56 0 | 1861 | | | |
| Port Neville | 50 31 0 | 126 04 0 | 1860 | | | |
| Anchorage cove, Kingcome inlet .. | 50 52 8 | 126 11 7 | 1881 | Aug. 3 | | 25 42 7 " |
| Nootka sound, Vancouver island | 49 36 0 | 126 37 0 | 1778 | | | |
| " | " | " | 1791 | | | |
| " | " | " | 1792 | | | |
| Friendly cove, | 49 35 5 | 126 37 5 | 1881 | Sept. 27 | | 23 36 2 " |
| Beaver harbour | 50 43 0 | 127 25 0 | 1860 | | | |
| North harbour, Quatsino sound | 50 29 4 | 128 03 6 | 1881 | Sept. 24, 25 | | 24 53 7 " |
| Port McLoughlin | 52 08 4 | 128 10 3 | | Aug. 7 | | 26 42 9 " |

SESSIONAL PAPER No. 25a

IX—Con.

RESULTS—Con.

COLUMBIA—Con.

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Tempe- rature. | Observer. |
|-------------------|------------------------|---------|-------------------|------------------------|-----------------|------------------|-------------------|--------------------|
| Aug. 30, 31. | | 74 20.9 | Aug. 30, 31. | | 1639 | | | C. A. French. |
| Sept. 1. | | 74 18.4 | Sept. 1. | | 1647 | | | " " |
| May. | | 74 50.0 | | | | 5985 | | D. Douglas. |
| Aug. 26, 27. | | 74 51.1 | Aug. 26, 27. | | 1586 | | | C. A. French. |
| | | 74 49.0 | " 28. | | 1591 | | | " |
| May 26. | 3-10 | 71 58.6 | May 26. | 3-48 | | 6030 | 68 | W. Ogilvie. |
| " 26. | to 3-43p 5-00 | 71 59.0 | " 26. | to 4-15p 4 20 | | 6064 | 66 | " |
| Sept. | | 72 02.0 | Sept. | | | 6114 | | J. S. Harris. |
| { Sept. 8, 9 } | | 71 57.0 | { Sept. 8, 9 } | | | 6106 | | J. S. Harris. |
| { Oct. 18 } | | | { Oct. 18 } | | | | | |
| June 3. | 2-15 to 2-52p | 72 13.0 | June 3. | 2-55 to 3-30p | | 6118 | 70 | W. Ogilvie. |
| " 3. | 4-12 to 4-35p | 72 10.5 | " 3. | 3-36 to 3-50p | | 6102 | 70 | " |
| | | 72 15.0 | | | | | | Richards. |
| | | 71 51.5 | | | 1870 | | | British Navy. |
| Oct. 6-8. | | 71 42.4 | Oct. 7, 8. | | 1878 | | | C. A. French. |
| " 3. | | 71 43.7 | " 3. | | 1867 | | | " |
| | | 72 14.0 | | | | | | Richards. |
| Oct. 12-14. | | 71 19.3 | Oct. 13, 14. | | 1876 | | | C. A. French. |
| " 10. | | 71 17.0 | " 10. | | 1878 | | | " |
| | | 71 18.1 | | | 1881 | | | C. I. |
| | | 71 39.0 | | | | | | K. Friesach. |
| May 4. | | 71 22.1 | May 4. | | | 5925 | | W. H. Dall & Baker |
| | | 71 39.0 | | | | | | Richards. |
| | | 71 30.3 | | | 1881 | | | C. S. |
| | | 71 34.1 | { Jan. 24 } | | | 6042 | | R. W. Haig. |
| | | | { Mar. 22 } | | | | | |
| | | 71 52.0 | | | | | | Richards. |
| | | 71 27.4 | | | 1905 | | | French Navy. |
| | | 71 32.4 | | | 1868 | | | British Navy. |
| Oct. 17, 18. | | 71 20.2 | Oct 17. | | 1883 | | | C. A. French. |
| " 18. | | 71 21.5 | " 18. | | 1879 | | | " |
| " 6. | | 71 42.2 | Oct. 7. | | | 3973 | | H. E. Nichols. |
| May 6. | | 71 29.2 | | | | | | W. H. Dall & Baker |
| | | 71 54.0 | | | | | | Richards. |
| June. | | 76 09.0 | June. | | | 6090 | | D. Douglas. |
| " | | 75 48.0 | June. | | | 6059 | | " |
| | | 71 53.6 | | | 1844 | | | British Navy. |
| | | 71 56.5 | | | 1854 | | | " |
| | | 71 30.2 | | | | | | C. S. |
| | | 71 26.4 | | | 1898 | | | C. S. |
| | | 71 24.2 | | | 1901 | | | C. S. |
| | | 71 25.3 | | | 1910 | | | " |
| July 30. | | 71 58.6 | July 30. | | | 5969 | | H. E. Nichols. |
| | | 72 25.0 | | | | | | Richards. |
| | | 72 37.0 | | | | | | " |
| | | 72 19.0 | | | | | | " |
| Aug. 3. | | 72 46.1 | Aug. 3. | | | 5928 | | H. E. Nichols. |
| April | | 72 29.0 | | | | | | J. Cook. |
| Aug. 16, 17. | | 70 20.7 | | | | | | Don. A. Malespina. |
| Oct. | | 73 56.0 | | | | | | G. Vancouver. |
| Sept. 26. | | 71 33.0 | Sept. 27. | | | 5950 | | H. E. Nichols. |
| | | 72 37.0 | | | | | | Richards. |
| Sept. 22. | | 71 41.3 | Sept. 24, 25. | | | 5942 | | H. E. Nichols. |
| Aug. 5, 6. | | 73 12.1 | Aug. 7. | | | 6038 | | " |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

BRITISH

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|---|-----------|------------|-------|-------------------------------------|------------------|--------------|
| | | | | Between July 27 and August 12 | | ° ' " |
| Salmon cove, Observatory inlet | 55 15.6 | 129 52.0 | 1793 | August 12 | | 25 18.0 " |
| Port Simpson..... | 54 33.6 | 130 22.8 | 1881 | Aug. 10, 12. | | 27 54.1 " |
| " | 54 33.5 | 130 23.8 | 1862 | | | |
| Rose harbour, Queen Charlotte island. | 32 09.1 | 131 15.0 | 1881 | Sept. 20.... | | 26 00.6 " |
| Lake Lindeman... .. | 59 47.2 | 135 04.8 | 1887 | June 25... | 1-00p | 32 16.8 " |
| " | " | " | " | | | |

SESSIONAL PAPER No. 25a

I X.—*Con.*RESULTS.—*Con.*COLUMBIA—*Con.*

| Month and day. | Hour and minute. | Dip | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Tempe- rature. | Observer. |
|--------------------------------------|------------------------|---------|-------------------|------------------------|-----------------|------------------|-------------------|----------------|
| Between July 27 and August 12. | | 75 54.5 | | | | | | |
| Aug. 9. | | 74 21.0 | Aug. 10, 12. | | | 5987 | | Vancouver. |
| | | 74 53.0 | | | | | | H. E. Nichols. |
| | | | | | | | | Richards. |
| Sept. 19. | | 72 30.2 | Sept. 20. | | | 5957 | | H. E. Nichols. |
| | 10-55 | | | 11-23 | | | | |
| June 25. | to 11-19a | 77 03.9 | June 25 | to 11-50a | | 5987 | 56 | Wm. Ogilvie. |
| | 0-19 | | | 11-52a | | | | |
| " 25. | to 0-47p | 77 06.5 | " 25. | to 0-13p | | 5973 | 56 | " |

9-10 EDWARD VII., A. 1910

TABLE
MAGNETIC
YUKON AND
(North of

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|----------------------------------|-----------|------------|-------|----------------|------------------|--------------|
| | ° ' " | ° ' " | | | | ° ' " |
| Portage du Grand Détour... | 60 22 0 | 113 00 0 | 1844 | June 25... | 5-38p | 35 15 0 E. |
| Fort Resolution..... | 60 10 7 | 113 46 0 | 1825 | | | 29 15 6 " |
| "..... | " | " | 1844 | June 22... | 10-20a | 37 12 5 " |
| "..... | " | " | " | | | |
| "..... | " | " | 1888 | Sept. 20... | 4-45p | 38 20 2 E. |
| "..... | " | " | " | | | |
| Fishing station, Little lake.... | 61 11 7 | 116 38 0 | 1844 | June 20.... | 6-02a | 35 28 0 E. |
| "..... | " | " | " | | | |
| Fort Confidence..... | 66 54 0 | 118 49 0 | 1839 | | | |
| "..... | " | " | 1849 | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | 1850 | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| Fort Simpson..... | 61 51 7 | 121 25 3 | 1825 | | | |
| "..... | " | " | 1844 | Mar. 30... | 7-58a | 37 32 0 E. |
| "..... | " | " | " | " 30.... | 9-13a | 38 43 0 " |
| "..... | " | " | " | " 30.... | 3-46p | 37 28 0 " |
| "..... | " | " | " | " 30.... | 4-56p | 38 02 0 " |
| "..... | " | " | " | May 8.... | 9-00a | 37 57 0 " |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | 1888 | Aug. 27.... | 8-20a | 37 42 4 E. |
| "..... | " | " | " | | | |
| Fort Norman..... | 64 40 6 | 124 44 8 | 1844 | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | 64 54 3 | 125 43 1 | 1888 | July 29.... | 8-15p | 33 39 0 E. |
| "..... | " | " | " | | | |
| Mackenzie river..... | 64 26 7 | 125 03 8 | " | Aug. 5.... | 7-17p | 41 34 6 " |
| "..... | " | " | " | | | |
| Fort Good Hope..... | 66 16 0 | 128 31 0 | 1844 | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |
| "..... | " | " | " | | | |

SESSIONAL PAPER No. 25a

X.

RESULTS.

NORTHWEST TERRITORIES.

Latitude 60°).

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Tem- perature | Observer. |
|----------------------|------------------------|-----------|----------------------|------------------------|-----------------|------------------|------------------|------------------------------|
| | | ° ' " | | | | | ° | |
| June 25.... | | 82 33·6 | | | | | | J. H. Lefroy. |
| June 22.... | a.m. | 82 43·5 | June 22.... | | | 6428 | | J. Franklin. |
| " 22.... | a.m. | 82 45·4 | " 22.... | | | 6439 | | J. H. Lefroy. |
| | | | " 22.... | | | 6437 | | " |
| Sept. 19.... | 4-00 to 4-23p | 82 10·1 | Sept. 19.... | 4-34 to 4-49p | | 6308 | 60 | Wm. Ogilvie. |
| " 19.... | 5-15 to 5-32p | 82 08·0 | " 19.... | 4-51 to 5-08p | | 6307 | 60 | " |
| Mar. 18.... | | 82 08·7 | June 20.... | | | 6390 | | J. H. Lefroy. |
| June.... | | 84 48·0 | " 20.... | | | 6369 | | " |
| October.... | | 84 49·4 | October.... | | | 6289 | | T. Simpson. |
| November.... | | 84 51·1 | " | | | 6179 | | J. Rae & J. Rich- ardson. |
| December.... | | 84 50·0 | November.... | | | 6101 | | " |
| | | | December.... | | | 6454 | | " |
| | | | " | | | 5994 | | " |
| January.... | | 84 48·8 | " | | | 6567 | | " |
| February.... | | 84 53·9 | January.... | | | 6467 | | " |
| March.... | | 84 50·4 | February.... | | | 6162 | | " |
| | | | " | | | 6406 | | " |
| | | | March.... | | | 6101 | | " |
| | | | " | | | 6363 | | " |
| Aug. 5.... | | 81 53·1 | " | | | | | J. Franklin. |
| Mar. 28.... | 4-05p | 81 53·8 | May 2.... | | | 6314 | | J. H. Lefroy. |
| May 12.... | 12-00a | 81 50·7 | " 2.... | | | 6394 | | " |
| | | | " 2.... | | | 6344 | | " |
| | | | " 2.... | | | 6411 | | " |
| | | | " 2.... | | | 6388 | | " |
| | | | June 12.... | | | 6373 | | " |
| | | | " 12.... | | | 6334 | | " |
| | | | " 12.... | | | 6373 | | " |
| | | | " 12.... | | | 6427 | | " |
| | | | " 12.... | | | 6350 | | " |
| Aug. 25.... | 6-00 to 6-20p | 81 17·2 | Aug. 25.... | 6-23 to 6-44p | | 6249 | 66 | Wm. Ogilvie. |
| " 27.... | 5-41 to 6-03a | 81 20·9 | " 27.... | 6-06 to 6-26a | | 6230 | 46 | " |
| " 27.... | 6-56 to 7-16a | 81 17·4 | " 27.... | 6-30 to 6-47a | | 6225 | 46 | " |
| May 28.... | | 82 34·3 | May 28.... | | | 6250 | | J. H. Lefroy |
| | | | June 2.... | | | 6235 | | " |
| | | | " 2.... | | | 6304 | | " |
| | | | " 2.... | | | 6385 | | " |
| July 29.... | 5-15 to 5-35p | 81 59·1 | July 29.... | 5-40 to 6-00p | | 6154 | 76 | Wm. Ogilvie. |
| " 29.... | 7-38 to 8-00p | 82 01·9 | " 29.... | 6-03 to 6-40p | | 6156 | 74 | " |
| Aug. 5.... | 4-48 to 5-06p | 81 58·2 | Aug. 5.... | 5-12 to 5-30p | | 6142 | 68 | " |
| " 5.... | 6-35 to 6-55p | 81 54·0 | " 5.... | 5-35 to 6-00p | | 6176 | 66 | " |
| May 29.... | 10-40p | 82 55·8 | May 29.... | | | 6268 | | J. H. Lefroy. |
| " 29.... | 10-40p | 82 56·1 | " 29.... | | | 6277 | | " |
| | | | " 29.... | | | 6297 | | " |
| | | | " 29.... | | | 6297 | | " |
| | | | " 29.... | | | 6409 | | " |

9-10 EDWARD VII., A. 1910

TABLE

MAGNETIC

YUKON AND

(North of

| Place. | Latitude. | Longitude. | Year. | Month and day. | Hour and minute. | Declination. |
|-----------------------------|-----------|------------|-------|----------------|------------------|--------------|
| Fort Good Hope. | 66 16.0 | 128 50.0 | 1888 | July 13... | 6-10p | 41 30.9 E. |
| " | " | " | " | " | " | " |
| Marsh lake, Yukon river. | 60 21.1 | 134 17.2 | 1887 | July 17... | 6-15p | 32 46.1 E. |
| " | " | " | " | " | " | " |
| Fort McPherson. | 67 26.0 | 134 57.0 | 1888 | June 22... | 4-25p | 46 00.8 E. |
| " | " | " | " | " | " | " |
| Lewes river | 60 42.3 | 135 04.1 | 1887 | June 24 | 6-40p | 30 55.7 E. |
| " | " | " | " | " | " | " |
| " | 62 04.4 | 136 04.0 | " | Aug. 7... | 7-20p | 33 54.8 E. |
| " | " | " | " | " | " | " |
| Fort Selkirk | 62 47.6 | 137 24.9 | " | Aug. 18... | 6-00p | 34 18.0 E. |
| " | " | " | " | " | " | " |
| Richardson's Chain | 69 01.0 | 137 25.0 | 1826 | " | " | " |
| La Pierre's House. | 67 23.0 | 136 54.0 | 1888 | " | " | " |
| " | " | " | " | " | " | " |
| Yukon river | 63 20.3 | 139 28.5 | 1887 | Aug. 27... | 5-40p | 33 52.8 E. |
| " | " | " | " | " | " | " |
| Mouth of White river. | 63 11.9 | 139 37.8 | " | Aug. 26... | 9-45a | 34 27.0 E. |
| " | " | " | " | " | " | " |
| Porcupine river | 65 43.0 | 139 40.0 | 1888 | May 16... | 11-45a | 37 44.3 E. |
| " | " | " | " | " 20... | 7-02p | 37 24.2 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| Yukon river | 64 25.5 | 140 31.7 | 1887 | Sept. 12. | 10-15a | 35 01.1 E. |
| " | " | " | " | " | " | " |
| Clarence bay, Arctic ocean. | 69 38.0 | 140 51.0 | 1826 | " | " | " |
| Boundary, Observatory. | 64 41.0 | 140 54.0 | 1888 | Feb. 27... | 4-15p | 35 45.3 E. |
| " | " | " | " | " 28... | 11-45a | 35 47.5 " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |
| " | " | " | " | " | " | " |

SESSIONAL PAPER No. 25a

X—*Con.*RESULTS—*Con.*NORTHWEST 1 *RIES—Con.*

Latitude 60°).

| Month and day. | Hour and minute. | Dip. | Month and day. | Hour and minute. | Hor. intens. | Total intens. | Temperature | Observer. |
|----------------|--------------------|---------|-----------------|--------------------|--------------|---------------|-------------|--------------|
| | | ° | | | | | ° | |
| July 13. . . | to 4-05 4-26p | 82 17 9 | July 13. . . | to 4-33 4-54p | | 6123 | 72 | Wm. Ogilvie. |
| " 13. . . . | to 5-20 5-44p | 82 18 9 | " 13. . . | to 4-58 5-17p | | 6117 | 72 | " |
| July 17. . . | to 4-39 5-05p | 77 31 1 | " 17. . . . | to 5-41 6-01p | | 6035 | | " |
| " 17. . . . | to 6-08 6-31p | 77 33 7 | " 17. . . . | to 5-08 5-33p | | 6009 | | " |
| June 22. . . . | to 2-15 2-35p | 81 51 8 | June 22. . . . | to 2-38 2-55p | | 6089 | 72 | " |
| " 22. . . . | to 3-44 4-06p | 81 45 0 | " 22. . . . | to 2-58 3-18p | | 6085 | 73 | " |
| July 24. . . . | to 4-22 4-50p | 77 42 8 | July 24. . . . | to 4-55 5-14p | | 5948 | 76 | Wm. Ogilvie. |
| " 24. . . . | to 6-05 6-35p | 77 45 2 | " 24. . . . | to 5-18 5-36p | | 5935 | 76 | " |
| Aug. 7. . . . | to 5-02 5-24p | 78 16 4 | Aug. 7. . . | to 5-30 5-52p | | 6026 | 72 | " |
| " 7. . . . | to 6-40 7-00p | 78 16 4 | " 7. . . . | to 5-55 6-13p | | 6023 | 70 | " |
| " 18. . . . | to 4-00 4-22p | 79 08 2 | " 18. . . . | to 4-28 4-50p | | 6019 | 81 | " |
| " 18. . . . | to 5-14 5-40p | 79 08 4 | " 18. . . . | to 4-53 5-09p | | 6012 | 78 | " |
| | | 82 22 0 | | | | | | J. Franklin. |
| June 7. . . . | to 8-12 8-32p | 81 23 7 | June 7. . . . | to 8-36 8-55p | | 5989 | 48 | Wm. Ogilvie. |
| " 7. . . . | to 9-22 9-40p | 81 25 7 | " 7. . . . | to 9-00 9-18p | | 5995 | 48 | " |
| Aug. 27. . . . | to 3-25 3-45p | 78 35 2 | Aug. 27. . . . | to 3-50 4-10p | | 5960 | 67 | " |
| " 27. . . . | to 4-48 5-12p | 78 38 3 | " 27. . . . | to 4-22 4-44p | | 5965 | 64 | " |
| " 26. . . . | to 8-00 8-25a | 78 30 3 | " 26. . . . | to 8-28 8-50a | | 5966 | 54 | " |
| " 26. . . . | to 9-15 9-40a | 78 18 6 | " 26. . . . | to 8-55 9-12a | | 5971 | 55 | " |
| May 16. . . . | to 9-45 10-07a | 79 57 6 | May 16. . . . | to 10-15 10-33a | | 6023 | 44 | " |
| " 16. . . . | to 11-00 11-18a | 79 57 1 | " 16. . . . | to 10-39 10-55a | | 6012 | 44 | " |
| " 20. . . . | to 4-24 4-45p | 79 51 5 | " 20. . . . | to 4-50 5-06p | | 5949 | 41 | " |
| " 20. . . . | to 5-30 5-55p | 79 53 2 | " 20. . . . | to 5-08 5-26p | | 6004 | 41 | " |
| Sept. 12. . . | to 7-12 8-20a | 78 45 5 | Sept. 12. . . . | to 8-25 8-40a | | 5942 | 46 | " |
| " 12. . . . | to 9-15 9-35a | 78 46 9 | " 12. . . . | to 8-47 9-10a | | 5930 | 48 | " |
| | | 83 27 0 | | | | | | J. Franklin. |
| Jan. 3. . . . | to 0-40 1-22p | 78 49 7 | Jan. 3. . . . | to 1-40 1-50p | | 5994 | 10 | Wm. Ogilvie. |
| " 3. . . . | to 2-25 2-50p | 78 50 1 | " 3. . . . | to 1-55 2-20p | | 5995 | 9 5 | " |
| Feb. 27. . . . | to 1-40 2-01p | 78 50 0 | Feb. 27. . . . | to 2-12 2-30p | | 6004 | 12 | " |
| " 27. . . . | to 3-10 3-20p | 78 48 9 | " 27. . . . | to 2-45 3-00p | | 5993 | 12 | " |
| " 28. . . . | to 9-25 9-43p | 78 48 6 | " 28. . . . | to 9-55 10-00a | | 6005 | 7 | " |
| " 28. . . . | to 10-53 11-10a | 78 50 1 | " 28. . . . | to 10-20 10-34a | | 6004 | 9 | " |

9-10 EDWARD VII., A. 1910

Comparison at Agincourt.

On July 9, 1908, a series of readings were taken with magnet 10, Tesdorpf magnetometer 1977, magnet erect, and magnet inverted.

| | |
|---|------------|
| The resulting declination July 9, at 14 ^h 33 ^m was. | 6° 01'·4 W |
| Observatory standard magnetometer. | 5° 57'·6 |
| Similarly on July 11 at 14 ^h 05 ^m , Tesdorpf. | 6° 03'·1 |
| Observatory. | 6° 00'·4 |
| Mean difference O - T. | — 3'·2 |

Hence west declinations as observed with the Tesdorpf instrument must be numerically decreased by 3'·2, and east declinations increased numerically by the same amount.

For horizontal intensity the following comparisons were obtained:—

| | |
|--|-------------------------|
| July 10 at 14 ^h 05 ^m , Tesdorpf. | ·16400 in C.G.S. units. |
| “ 14 ^h 05 ^m , Observatory. | ·16387 “ |
| “ 16 ^h 33 ^m , Tesdorpf. | ·16391 “ |
| “ 16 ^h 33 ^m , Observatory. | ·16379 “ |
| July 11 at 10 ^h 23 ^m , Tesdorpf. | ·16356 “ |
| “ 10 ^h 23 ^m , Observatory. | ·16349 “ |
| “ 11 ^h 44 ^m , Tesdorpf. | ·16365 “ |
| “ 11 ^h 44 ^m , Observatory. | ·16357 “ |
| Mean difference, O - T. | ·00010 |

This is equivalent to ·00061 *H*, which is the quantity to be deducted from observed values of *H*. In figures 2, 3, 4, are shown the observations made for ascertaining the effect, if any, of the electric car service already referred to. The smooth curves drawn exhibit the diurnal variation clearly, showing the hours of the day when it changes most rapidly.

It will be seen that for April 24, 1909, the range was nearly 17 minutes of arc.

In figure 5, is shown a curve based upon the one of the preceding date. This curve represents the actual line that would be run by a surveyor with a compass in trying to lay down a true N.-S. line, starting at 7 a.m. of that day, getting half-mile sights, then resetting at hour intervals, always with the same magnetic reading of the compass without getting back-sights on the preceding station. The scale of offsets is much exaggerated in the figure.

The result would be that after running six miles by evening, he would be 104 links or about 69 feet west of the line on which he started in the morning.

This shows the theoretical inaccuracy of a compass line due to diurnal variation alone. Of course with the ordinary surveyor's compass it is not possible to read to single minutes, far less to fractions thereof such as enter into the above curve. But the point is, one cannot get away from the important effect of diurnal variation, though it be masked by larger errors of reading. When compass lines are, or were, run in the open a fairly straight line could be run by using back-sights or simply 'picketing' the line, but this condition was rarely the case; the most of the compass lines were run through the woods, the trees being 'blazed' along the line, those on the line were 'notched' and left standing, and the compass simply put on the other side of the obstruction and the line continued on the same bearing as near as it was possible to read the needle.

The actual magnetic bearings of the astronomic north and south line at Ottawa on that day were:

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| Hour. | Bearing. | Offset at end of each course from true N.-S. line of first course. |
|---------------------------------|-------------|--|
| 7 ^h (a.m.) | 12° 52'.4 W | 0.0 links. |
| 8. | 51.2 | 1.4 " |
| 9. | 51.0 | 3.0 " |
| 10. | 54.8 | 0.2 " |
| 11. | 59.0 | 7.7 " |
| 12. | 13° 03'.0 | 19.8 " |
| 13. | 6.0 | 35.5 " |
| 14. | 7.4 | 52.8 " |
| 15. | 6.4 | 69.5 " |
| 16. | 4.4 | 83.2 " |
| 17. | 2.4 | 95.0 " |
| 18. | 0.5 | 104.4 " |

For the coming season it is intended to send the observer along the northern shore of the St. Lawrence from Quebec eastward to Blanc Sablon, near the western entrance of the strait of Belle Isle. The data from this territory are very meagre, so that the magnetic elements to be derived on this stretch of about 750 miles will be of particular value.

The accompanying map shows the position of the various stations given in the table, and the direction of the magnetic meridians at the respective stations or places.

GRAVITY.

During the past season no member of the staff was available for making gravity observations.

I have the honour to be, sir,

Your obedient servant

OTTO KLOTZ.



FIG. 1—Magnetic Hut, Ottawa.

Diurnal Variation Curve

Ottawa

April 24 1909

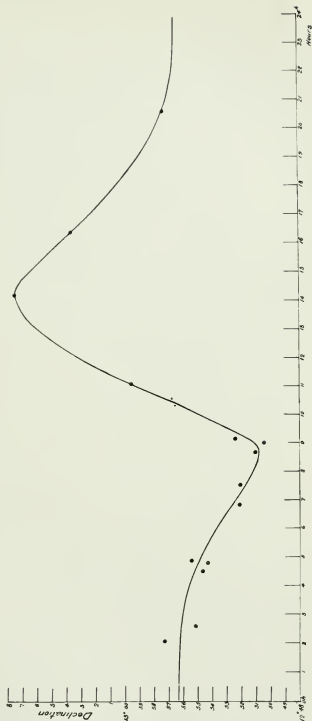


FIG. 2.

Diurnal Variation Curve
Ottawa
April 29 1909

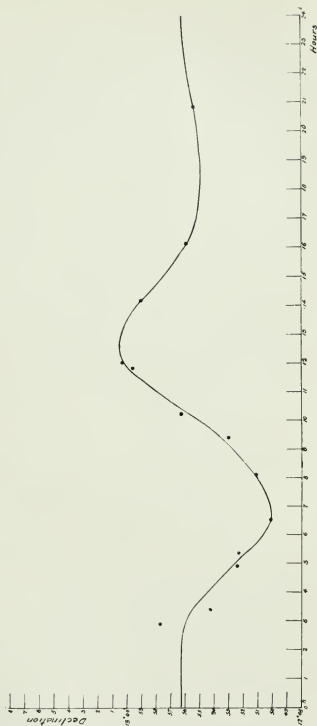


FIG. 3.

Diurnal Variation Curve
Orleans
May 7 1909

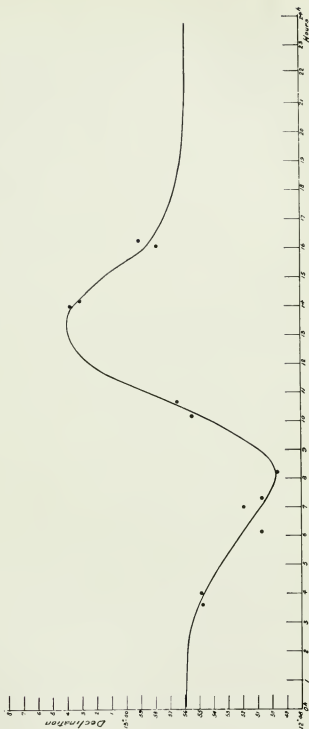
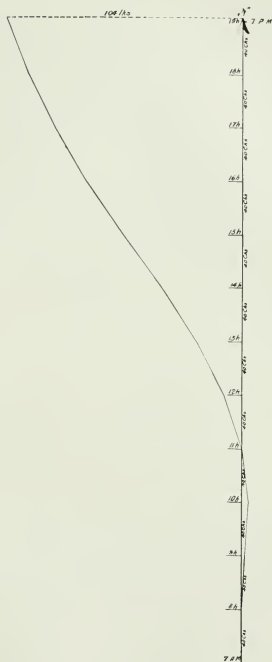


FIG. 4.

Survey Curve

APPENDIX 2.

REPORT OF THE CHIEF ASTRONOMER, 1909.

ASTROPHYSICAL WORK

BY

J. S. PLASKETT, B.A.

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APPENDIX 2.

ASTROPHYSICAL WORK BY J. S. PLASKETT, B.A.

OTTAWA, March 31, 1909.

W. F. KING, C.M.G., LL.D.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR,—I have the honour to submit the following report upon the work carried on in the Astrophysical Department and in the other departments of the work of the Observatory under my direction during the past year.

It gives me pleasure to report satisfactory progress in all lines and to state that the work accomplished both in quality and quantity shows gratifying improvement over the records of previous years. As in previous years also it has been found necessary to spend considerable time in preparatory work, in testing, adjusting, and perfecting the instruments and appliances used, and in experimenting to determine the best methods of procedure. Although the time spent on such work necessarily diminishes the quantity of routine work accomplished, it is in my opinion time well spent, if through such investigations and experiments we are in a position to do a larger quantity of more accurate work. Consequently, much of my time during the past year has been devoted to investigations bearing on improvements in instruments and methods, of which full details will be given later.

It gives me much pleasure to be able to speak in the highest terms of the very satisfactory work done by my assistants, Messrs. Harper, Motherwell, DeLury, Cannon and Parker.

As heretofore, the principal work has been the determination of the radial velocities of stars by means of the spectroscope, and in this work observations have been chiefly confined to known spectroscopic binaries for the determination of the elements of their orbits. However, observations on some stars with early type spectra have also been secured during times when sufficient binaries have not been available, and in measuring up the plates we have found the velocities of four of these stars to be variable; δ Herculis, γ Aquarii, ι Andromedæ, ξ Persei. The two latter, it has since been learned, had been previously found variable at the Yerkes Observatory, but not published, so that our discovery was independent.

The elements of the orbits of five spectroscopic binaries have been obtained, least squares corrections being applied in every case. The stars are θ Aquilæ, α Coronæ Borealis, η Boötis, ϵ Herculis, β Orionis. These stars will be discussed in detail below, but it may be of interest to mention that only in one case, η Boötis, have the observations been entirely satisfied by velocity curves due to simple elliptic orbits. In θ Aquilæ and ϵ Herculis a secondary disturbance due possibly to a third body, has been present. In α Coronæ Borealis the elements deduced from the hydrogen lines and the calcium, K , line differ from those obtained from the magnesium $\lambda 4481.4$, while in β Orionis the amplitude of the velocity seems to be variable. This latter is of especial interest on account of the measures made at Yerkes and Lick Observatories showing its velocity to be constant within the apparent errors of observation.

Besides the binaries above, whose orbits have been determined, there are twelve others under observation, on three or four of which the work is well advanced. On the remainder, however, a considerable number of observations are still required. About 90 per cent of the binaries observed here are stars of early type, in the majority of which the lines in the spectra are broad and diffuse, in some cases unsymmetrically so, and consequently difficult of measurement. In such cases the agreement among the lines in a plate is poor and the error of measurement is high, the probable errors of single plates being as great as 7km. per second in some cases. It is evident that, unless there is a large range of velocity, the elements of the orbits of such stars are subject to considerable uncertainty, and indeed in several cases the star has had to be abandoned on this account after considerable work had been done on it.

The instrumental equipment for this work has been increased since my last report by the addition of a new single-prism spectrograph designed by myself, and constructed, except the optical parts, entirely in our own workshop. Owing to press of repair and other work it was not completed and put into commission until about the first of March, but it has fulfilled all expectations both as regards shortening of exposure time and in respect to its stability and freedom from flexure. The displacement of the spectrum lines produced by a revolution of 180° , this producing the maximum amount of flexure, is quite unmeasurable and is not even certainly visible under high power magnification; there is no question but that it is the most stable single-prism spectrograph ever constructed. The difference between it and the previous instrument, which was for its type a rigid example, is very marked, the displacement in the early instrument being equivalent to a velocity of over 100km. per second.

My investigation on the fields given by different types of camera objectives for spectrographs was completed, and a concise account of the performance of all the objectives tested will be given below and will also appear in the *Astrophysical Journal* in May. Since my previous report a new single material Brashear objective for the new single prism spectrograph has been received and tested. Its angular aperture is about 50 per cent greater than the original one and when received, owing to the greater difficulty in correction, it had a small amount of positive aberration. By the kindness and through the skill of Mr. McDowell this aberration was finally removed and the objective is now practically perfect for its purpose. A special short focus objective by Ross has also been received and tested, giving beautiful definition and a fairly flat field. Thus, the requirements for all types of camera objectives have been successfully met, and there are now available suitable objectives for all classes of radial velocity and other spectroscopic work.

The investigation on the effect of increasing the slit width on the errors of measurement in radial velocity work has been continued with the two different dispersions now available. The new single-prism spectrograph and a short focus objective with the three prism instrument have been tested, giving results that bear out and extend those previously obtained. It is shown that, so far as early type spectra are concerned, both accidental and systematic errors approach a minimum value for a slit 0.051mm. wide and that the use of a narrower slit, instead of increasing the accuracy as has generally been supposed, has to a certain degree the opposite effect, to say nothing of the proportional increase of exposure required. A detailed report of this work will be postponed to allow it to be finally completed.

In presenting the work on radial velocities and allied investigations in detail, I have adopted the same plan as last year, of having each observer give the details and results of the work he has been engaged on. Consequently, below will be found, besides my own remarks on radial velocities in general, my description of the new spectrograph, the investigations on camera objectives and on the effect of slit width, and the orbit of β Orionis, the orbits of θ Aquilæ, η Boötis and ϵ Herculis by Mr. Harper, and the orbit of α Coronæ Borealis by Mr. Cannon. Mr. Parker, the third observer in radial velocity work, besides measuring many miscellaneous plates, spent

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a great deal of time on the binary τ Tauri, but owing to difficulties due to causes outlined above was unable to obtain a satisfactory orbit and further observations next season will probably be necessary.

Work with the coelostat telescope in spectroscopic investigations of the sun has made satisfactory progress, although not as much has been accomplished as we had hoped. This has been due to various unavoidable constructional delays in having the 23-foot spectrograph and its attachments completed, to a long delay while the solar research laboratory was torn up for the installation of underground pipes and an electric pump for draining the transit house piers, and to a very thorough investigation of some peculiar properties in the plane grating used as the dispersion piece in the spectrograph. This investigation, which is fully described by Dr. DeLury below, showed that only by masking part of the grating could even fair definition be secured, while the best definition is necessary for accurate results in the determination of the solar rotation. A number of plates for this purpose have been secured and some preliminary measures by Dr. DeLury will be given. An illustrated description of the coelostat telescope and mechanism will be given by myself, and a description of the spectrograph and attachments by Dr. DeLury.

Mr. Motherwell has used the equatorial on three half nights per week in micrometric measures of double stars and has obtained a number of good measures, although his, as well as all other work with the telescope, has been much handicapped by the exceptionally poor observing weather of last fall and early winter. For nearly four months, smoke and cloud prevented almost all observations. This was especially unfortunate on account of the presence of Morehouse's comet, an especially interesting object, photographically, which this bad weather prevented from being photographed here more than half a dozen times. However, Mr. Motherwell will give an account in Appendix D of the double star measures obtained, of the occultations of stars by the moon observed, and of the photographs of the comet secured.

A full account of an interesting and useful investigation by Mr. Motherwell on the aberration of the 8" Brashear Photographic Doublet, used in making the comet pictures, will be given. When this instrument was first tested by me, soon after the Observatory was completed, it was found to give halos around the stars of medium intensity, while in the brighter stars this halo had become so fully exposed as to make images of uniform intensity and of large diameter. This difficulty I ascribed to spherical aberration, but this diagnosis was opposed by the makers of the lens.

I suggested to Mr. Motherwell as a suitable and useful subject for investigation to determine by Hartmann's method of extra-focal exposures the amount of spherical aberration present. His thorough tests showed the lens to have negative aberration to the extent of about 3.5mm., which in our opinion was quite sufficient to account for the halo observed. A suggestion of Mr. McDowell that it was due to chromatic aberration was found by Mr. Motherwell not to be the case. The matter remained in abeyance for some time, when on a further suggestion from Prof. Hastings the separation of the elements of the front component was changed to remove the halo, supposedly a 'ghost' due to internal reflections. However, a test showed no improvement on the original positions in the slight change proposed. Further correspondence with Mr. McDowell resulted in a suggestion from him to increase the separation by about 2mm., which would practically remove the aberration. On this being done and the distance adjusted so that the aberration was removed, the halo disappeared which was a striking confirmation of our contention that it was caused by aberration. A recent letter from Mr. McDowell admits that we were right as he had proved by refiguring a lens giving a similar halo.

In consequence, the objective will be sent to Alleghney to have this aberration removed and with its already very flat field we should have an unequalled star camera. In this regard, I would urge upon you the desirability of supplying the camera with a separate mounting. Its attachment to the equatorial telescope results in seriously

limiting its usefulness; for when star photographs are being made, no work, other than the guiding, can be done with the equatorial. A separate mounting, however, would enable the two to be used independently and much more use could be made of the camera than is possible at present.

The quantity of repair and other work has increased so greatly, that the two mechanicians, Mr. Mackey and Mr. Lucas, the latter having been appointed since my last report, have not been able to keep up with all the work required. Repairs and minor alterations in the field instruments used in the Geodetic and Boundary Surveys, occupy about one-half their time, leaving the remainder for new work. The new single-prism spectrograph, the mechanical parts of the solar 23-foot focus spectrograph, and new hardened steel pivots on the meridian circle are the principal pieces of work accomplished. Besides these are numerous smaller pieces of work. Scarcely a day passes that some work does not come in.

The equipment of the machine shop has been increased by a 14 inch by 7 foot Hendry Norton lathe, which is installed and in use. With two lathes there is now no possibility of delaying work for lack of tools. The lathe is the tool most used in machine work and frequently cases occurred where both men required the lathe at the same time; in consequence the work could not be done to the best advantage. The workshop is too small for the tools and the amount of work done, and moreover the light in it is not of the best. It is desirable that, as soon as possible, provision be made for a suitable workshop above ground with ample room and light. The necessity and economy of a suitably equipped workshop for the Observatory are so evident, and the probability of an increase in its capacity being required is so great, as to justify the question of a more suitable location than the present one being carefully considered.

The field instruments and others of a portable nature have been most carefully looked after by Mr. Motherwell, who has kept a careful record of their movements. This work has become, with the increase in the staff and in the number of instruments, one of considerable labour and trouble and takes much of his time in the spring and fall.

The Saturday open nights of the telescope for the public continue to be well patronized, the average attendance on fine nights being upwards of fifty, and much intelligent interest is manifested by many of the visitors in astronomy. This interest is further fostered by the papers presented at the evening meetings of the Royal Astronomical Society of Canada, of which the majority are given by officers of the Observatory. It may not be amiss here to refer also to the value of the work done by the members of the Observatory staff in the afternoon or technical lectures given alternately with the evening ones. These lectures and papers presenting in most cases original work in different lines of astronomy have been of great value, not only in keeping us acquainted with each other's work but also in encouraging researches along original lines which have been frequently of distinct value to science.

The following papers by members of the staff of the Astrophysical Division have been published since the date of the last report:—

1. The spectroscopic Binary ϵ Orionis, by J. S. Plaskett and W. E. Harper, *Astrophysical Journal* XXVII, p. 272, May, 1908.
2. Effect of increasing the slit-width upon the accuracy of Radial Velocity Determinations, by J. S. Plaskett, *Astrophysical Journal* XXVIII, p. 259, Nov., 1908.
3. The spectroscopic Binary ψ Orionis, by J. S. Plaskett, *Astrophysical Journal* XXVIII, p. 266, November, 1908.
4. The Orbit of ϵ Orionis, by J. S. Plaskett, *Astrophysical Journal* XXVIII, p. 274, November, 1908.
5. The Astronomical and Astrophysical Society of America, by J. S. Plaskett, *Journal of the Royal Astronomical Society of Canada* II, p. 255, September-October, 1908.

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6. The Reduction of Cadmium by Mercury and the Electro-Motive Force of Cadmium Amalgam, by R. E. DeLury and G. A. Hulett, *Journal of the American Chemical Society*, volume 30, No. 12, p. 1805, December, 1908.

7. Comet 1908 (Morehouse), by R. M. Motherwell, *Journal of the Royal Astronomical Society of Canada III.*, p. 28, January-February, 1909.

8. The Orbit of ϵ Aquile, by W. E. Harper, *Journal of the Royal Astronomical Society of Canada VII.*, p. 87, March-April, 1909.

Besides the above the following papers are to appear shortly, the work on them having been completed and sent to the publishers:—

9. Camera Objectives for Spectrographs, by J. S. Plaskett, *Astrophysical Journal*, May, 1909.

10. The Spectroscopic Binary β Orionis, by J. S. Plaskett, *Astrophysical Journal*, July, 1909.

11. The design of Spectrographs, by J. S. Plaskett, *Journal of the Astronomical Society of Canada*, May-June, 1909.

In addition to the above the Astrophysical Division have sent in the titles of the following seven papers to be read before the Royal Society of Canada at their meeting, May 25, 1909:—

12. A new Single Prism Spectrograph, by J. S. Plaskett.

13. Slit width and Errors of Measurement in Radial Velocity Determinations, by J. S. Plaskett.

14. The spectroscopic Binary β Orionis, by J. S. Plaskett.

15. The System of ϵ Herculis, by W. E. Harper.

16. Aberration of a Stellar Camera Objective, by R. M. Motherwell.

17. Convection and Stellar Variation, R. E. DeLury.

18. The Orbit of α Coronæ Borealis, by J. B. Cannon.

In general the work represented by these papers will appear in detail below, arranged sometimes in a little different form, and including as a rule the whole of the original measurements and data which were abbreviated or left out in the published papers.

THE SPECTROGRAPHS.

During the year just passed the Ottawa spectrograph, illustrated and described in the 1907 report, has been used almost entirely, the new single-prism spectrograph not having been ready for service until about March 1, 1909. The former instrument has been used mostly in the single-prism form, the three prisms having been used only for some plates of β Orionis and a few others. The spectrograph has not been changed in any way since the last report, and its performance has continued satisfactory. Nothing further need be added about this instrument, except that towards the close of the year the Zeiss Tessar objective of 300mm. focus, referred to in the last report, was temporarily mounted for the purpose of continuing the tests on the effect of slit-width on errors of setting so far as applies to a dispersion of three prisms with a short focus camera. This mount will be placed in a permanent form as soon as time can be found in the workshop, and used on solar type binaries too faint to be obtained with the long focus camera.

Before proceeding to describe the new single-prism spectrograph, which was briefly referred to in my last report, it has seemed desirable to enter more fully than was there done into the principles on which its design was based, and for this purpose I can not do better than give here a paper on 'The Design of Spectrographs,' which I read at an afternoon-technical meeting on May 25, 1908, and which will appear in the May-June number of the *Journal of the Royal Astronomical Society of Canada*.

THE DESIGN OF SPECTROGRAPHS FOR RADIAL VELOCITY DETERMINATIONS.

Read before R.A.S.C., May 28, 1908.

The subject of spectroscopy is so broad that one can not hope in a single paper to do more than touch upon a single aspect of it, and, even then, one must further limit his treatment to a particular application of this phase. Consequently, I propose to present some considerations bearing upon the design of spectrographs suitable for the accurate determination of stellar radial velocities. This branch of spectroscopy is comparatively new and is still probably only in the experimental and tentative stage. The present practice in this line has, however, reached a certain uniformity and the general theoretical principles governing the design of spectroscopes may be applied to the case under consideration, modified, of course, in many ways by the experience of the various observers. The question is one of a judicious combination of theory and experience, and I propose to present my own views, founded, of course, on theoretical considerations, but modified partly by the practice of other spectroscopists, partly by my own experience in the work and by the results of special investigations bearing on the most suitable form and dimensions of the instrument.

The determination of the radial velocities of stars by means of the spectroscope is one of the most exacting of astronomical investigations, and requires the closest attention to all details to ensure accurate values. This will be more readily recognized when the smallness of the displacement of the spectral lines on which the velocity depends is known. Thus, in the Ottawa Spectrograph a velocity of 20km. per second, which is greater than the average velocity of the stars, causes a displacement at $H\gamma$, the centre of the measurable range, of about $\frac{1}{2700}$ inch for the single-prism, and about $\frac{1}{500}$ inch for the three-prism form of the instrument. The accidental errors arising in the measurement of this displacement, in spectra with good lines, are, however, not so much to be feared as systematic displacements of the lines as a whole, of which no evidence is given in the measurements, caused by flexure of the parts of the spectrograph, by temperature changes in the prisms and lenses and also in the metal frame, by faulty adjustment of the focal positions of camera and collimator, as well as by numerous other causes. Some idea of the magnitudes of these displacements may be gained from the following figures. An hour's exposure in one of the modern spectrographs introduces flexure displacement equivalent, in some positions of the telescope, to a velocity of 10km. per second. A change of temperature of 1°C . in the prism displaces the lines by about 20km., which may be increased further by the expansion of the metal parts. An inaccuracy in the focal setting of the camera of only 0.1 mm. $\frac{1}{250}$ inch, may, when combined with poor guiding, cause a displacement of about 5km. It does not follow that such displacements necessarily cause a corresponding error in the velocity as they may be compensated for, partially at any rate, by a similar displacement of the comparison lines. But the possibility remains, and inaccurate results can only be prevented by constant and careful attention to all details. It becomes, therefore, a question of equally great importance with proportioning the optical parts to give accurately measurable spectra in the shortest possible exposure time, to so design the whole instrument that systematic errors due to the above or other causes may be provided for and eliminated as far as possible.

The design of a spectrograph may be most conveniently attacked under two separate headings:

1. The character and proportions of the optical parts.
2. The mechanical connection of these parts into a symmetrical and stable whole, with suitable auxiliary devices for controlling the temperature, applying comparison, &c.

The Optical Parts.

Up to the present, prisms of dense flint glass have been the sole dispersing medium used for radial velocity work. Gratings, so useful in other branches of spectroscopy, have not yet been applied in this work, chiefly on account of the division of the incident pencil into a number of spectra with the consequent loss of light, and also on account of the difficulty of maintaining their position invariable without distorting the surface. Prisms have very decided advantages over gratings in this respect as, when set at minimum deviation, a small angular rotation of the prism will scarcely displace the spectrum lines, while with a grating the angular displacement of the lines is double that of the prism. The optical parts of a spectrograph are then:—1. The slit, whose width is usually between 0.025 and 0.051mm., one and two thousandths of an inch, on which the star image is condensed by the telescope. 2. The collimating lens placed at its focal distance from the slit and consequently rendering the incident pencil parallel. 3. The prism or prisms placed at minimum deviation for some particular wave-length usually near $H\gamma$. 4. The camera lens which forms an image of the spectrum on the photographic plate.

As the terms dispersion, resolving power, purity, &c., will be frequently used and as the prism angle, thickness of base, &c., require computing, it seems preferable to give here a short synopsis of the theory involved and the formulæ used, particularly as these are not readily available in a suitable form or collected together in one place.

When a pencil of parallel white light is incident upon a prism, the direction is changed, the light is deviated, and it is also decomposed into its constituent colours forming a spectrum, the wave-lengths of the light giving rise to these colour-sensations, diminishing as you go from red to violet. The fundamental formula determining the direction after refraction is, i being the angle of incidence, r of refraction,

$$\sin i = \mu \sin r.$$

μ is the index of refraction which varies for different materials and for different wave-lengths in the same material, increasing as the wave length diminishes. In all spectroscopes the prisms are used at the position of minimum deviation, which, it may be easily shown, requires the angles of incidence and emergence to be equal. The discussion will therefore be confined to this particular case, resulting in a considerable simplification.

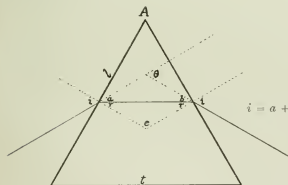


Fig. 1.

If a is aperture of incident pencil just filling prism,

$$l = a \sec i.$$

$$t = 2l \sin \frac{A}{2} = 2a \sec i \sin \frac{A}{2}.$$

$$A + e = 180^\circ$$

$$e + 2r = 180^\circ$$

$$\therefore r = \frac{A}{2};$$

$$\theta = a + b; \quad a = b,$$

$$\therefore a = \frac{\theta}{2}.$$

$$i = a + r = \frac{A + \theta}{2}, \text{ and as } \sin i = \mu \sin r,$$

$$\mu = \frac{\sin \frac{A + \theta}{2}}{\sin \frac{A}{2}}.$$

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' If θ the deviation and μ the index are given to find A or the angle of the prism,

$$\sin \frac{A + \theta}{2} = \mu \sin \frac{A}{2} \text{ and reducing and simplifying}$$

$$A = 2 \sin^{-1} \frac{\sin \frac{\theta}{2}}{\sqrt{\sin^2 \frac{\theta}{2} + \left(\mu - \cos \frac{\theta}{2} \right)^2}}.$$

' The dispersion of a prism is usually defined as the ratio of the change in deviation to the change in wave length or $\frac{d\theta}{d\lambda}$. As the deviation varies with the index of refraction and as the latter varies with the wave length we may put

$$\frac{d\theta}{d\lambda} = \frac{d\theta}{d\mu} \cdot \frac{d\mu}{d\lambda}, \text{ but}$$

$$\mu = \frac{\sin \frac{A + \theta}{2}}{\sin \frac{A}{2}}$$

$$\therefore \frac{d\theta}{d\mu} = \frac{2 \sin \frac{A}{2}}{\cos \frac{A + \theta}{2}} = \frac{2 \sin \frac{A}{2}}{\cos i}$$

$$= \frac{2 \sin \frac{A}{2}}{1 - \sin^2 i} = \frac{2 \sin \frac{A}{2}}{\sqrt{1 - \mu^2 \sin^2 \frac{A}{2}}}$$

$$\text{also } \frac{d\theta}{d\mu} = \frac{2 \sin i}{\frac{\mu}{\cos i}} = \frac{2}{\mu} \tan i.$$

' To obtain $\frac{d\mu}{d\lambda}$ we require a relation between λ and μ . The simplest is obtained from Hartmann's interpolation formula.

$$\mu = \mu_0 + \frac{c}{\lambda - \lambda_0}$$

$$\therefore \frac{d\mu}{d\lambda} = - \frac{c}{(\lambda - \lambda_0)^2} \text{ and consequently}$$

$$\frac{d\theta}{d\lambda} = \frac{d\theta}{d\mu} \cdot \frac{d\mu}{d\lambda} = - \frac{c}{(\lambda - \lambda_0)^2} \cdot \frac{2 \sin \frac{A}{2}}{\sqrt{1 - \mu^2 \sin^2 \frac{A}{2}}}.$$

' Let us now consider resolving power or the ability of the prism to separate lines close together in the spectrum. Lord Rayleigh has shown, in the case of the image of

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an infinitely narrow slit produced at the focus of a telescope lens, that the linear distance ξ of the first diffraction minimum from the principal maximum is given by the equation.

$$\frac{a \xi}{m \lambda f} = 1,$$

where a is the aperture and f the focus of the lens and m is a constant, 1.0 for rectangular and 1.2 for circular apertures.

$$\frac{\xi}{f} = \frac{m \lambda}{a}$$

$\frac{\xi}{f}$ is then the least angular distance at which two rays can be seen separated. Calling the angle $d\theta$ we have

$$d\theta = \frac{m \lambda}{a}.$$

For the case of a prism we have

$$a = l \cos i, \quad t = 2 l \sin \frac{A}{2}$$

$$\therefore \frac{t}{a} = \frac{2 \sin \frac{A}{2}}{\cos i} = \frac{d\theta}{d\mu}$$

Combining we get the minimum condition of resolution

$$t = \frac{m \lambda}{d\mu}$$

Again, omitting the constant m , we have

$$d\theta = \frac{t d\mu}{a} = \frac{\lambda}{a},$$

and multiplying by $\frac{a}{d\lambda}$ we get

$$a \frac{d\theta}{d\lambda} = t \frac{d\mu}{d\lambda} = \frac{\lambda}{d\lambda}$$

where $\frac{\lambda}{d\lambda}$ is the minimum value which permits resolution of close lines. $\frac{\lambda}{d\lambda}$ or the

ratio between the mean wave length of a pair of lines which can just be resolved in a spectroscope and the difference in wave length between the two components is called the resolving power of the spectroscope and is usually designated by the letter R .

'The linear dispersion $\frac{ds}{d\lambda}$ where f = focal length of camera is

$$\frac{ds}{d\lambda} = f \cdot \frac{d\theta}{d\lambda} = f \cdot \frac{R}{a}.$$

'The resolving power R refers to infinitely narrow lines through an infinitely narrow slit. When, as necessarily occurs in practice, neither of these two conditions holds, we speak of the purity of the spectrum or the practical resolving power for wide slits. Schuster has given a simple expression for the purity which is always a fraction of the theoretical resolving power R . This expression has been elaborated by Wadsworth

and later still Schuster has given tables for determining the purity. But as no appreciable error will be introduced in the relative values used in this work, it has seemed preferable to adhere to the simple form. If d = slit width and ψ = angular aperture of

the collimator = $\frac{a}{f}$, the Purity $P = \frac{\lambda}{d \psi + \lambda} \cdot R$.

'We have now obtained all the formulæ necessary to compute the data for any optical system and to compare the efficiency of different forms of spectroscopes. To take a concrete case, which is more applicable for our purpose than a general discussion, I propose to consider the question of the most suitable aperture to be given a single-prism spectrograph which is being constructed for the Dominion Observatory. The present spectrograph, which is arranged to be used with either one or three prisms, has a collimator of 35mm. aperture, 525mm. focus and two cameras, one for each form of 525mm. focus. It performs excellently for both purposes, but when, as often happens, both single and three prisms are required on the same night, the change from one form to the other is somewhat tedious, requiring 15 or 20 minutes, and moreover, what is far more important, such change involves uncertainties as to the temperature conditions of the optical parts and therefore corresponding uncertainties as to the accuracy of the velocities obtained.

'In order to fill the collimator lens completely with star light its aperture ratio $\frac{a}{f}$ must be the same as that of the equatorial. The aperture ratio of the Ottawa telescope is 1 to 15, consequently the focal length of the collimator must be 15 times the aperture. This aperture is limited on the lower side by the condition that sufficient purity must be obtained, purity being proportional to the aperture at a practicable width of slit, to so separate lines and blends of lines that sufficiently accurate identifications of lines and the true wave lengths of blends may be obtained. It is limited on the upper side by the difficulty of obtaining homogeneous prisms of large size, by the increased absorption of such prisms, and by the increased size and weight of the instrument. In all the spectrographs used in radial velocity work the apertures lie between 30 and 51mm., and these seem to be about the practical limits. It remains to determine the most suitable.

'The basis of the discussion* rests upon the results obtained for the effective diameter of the star image given in my paper on 'The Star Image in Spectroscopic Work,' No. II, which was read here last fall and published in the *Astrophysical Journal*, March, 1908. The results of a number of experiments, photographs of star images, spectra and trails, went to show that only very rarely is the effective diameter of the image less than 2 secs. of arc (about 0.055mm.) at the focus of the refractor. Generally the diameters of images and the widths of spectra and trails are considerably greater, increasing to over 0.1mm. with longer exposures. As the theoretical diameter of the central disc is only 0.57" (about 0.015mm.) and, as the condensing system of visual objective and photographic correcting lens is practically perfect, the enlargement in diameter is undoubtedly due to atmospheric disturbances. These consist probably partly of a blurring or spreading out of the central disc and partly of small displacements in all directions from its mean position. In consequence there results considerable loss of light at the slit jaws with the widths usually employed, and further experiments showed that the proportion transmitted varied almost directly with the width until this reached 3 or 4 secs. I reproduce below part of the table for slit transmission given in the paper referred to:—

* An able discussion of this subject on somewhat similar lines, to which I am much indebted, has been given by Newall (*M. N.* 65, p. 608).

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SLIT TRANSMISSION.

| Slit Width. | | Comparative exposure for equal intensity of spectrum. | |
|-------------|---------------|---|------------------------------------|
| Linear mm. | Angular secs. | Observed. | Corrected for loss by diffraction. |
| 0.025 | 0.91 | 100 | 100 |
| 0.051 | 1.82 | 40 | 50 |
| 0.076 | 2.73 | 27 | 35 |
| 0.102 | 3.64 | 25 | 32 |

This table shows that if the slit width can be increased the exposure is proportionally diminished, double the slit width halve the exposure, which means, of course, an increase in the output and in the practical range of the equipment. But on the other hand, a widening of the slit, other conditions remaining unchanged, decreases the accuracy of measurement of the resulting spectra. This loss of accuracy is due to two causes: first, diminished purity rendering uncertain identifications and wave lengths of blends; second, increased diffuseness of the spectral lines rendering measurements more difficult. We will take up these two considerations separately and find under what conditions the slit may be widened without loss of accuracy.

The equation for purity of spectrum, $P = \frac{\lambda}{d\psi + \lambda} \cdot R$, shows that the purity is almost proportionally diminished as the slit width is increased as $d\psi$ is, even for slit 0.025mm., nearly ten times λ . To increase the purity of a spectrum only two courses are open—to diminish the slit width or increase the resolving power. As we wish to widen the slit the resolving power of the spectroscope must be increased, which may be done in three ways.

1. By increasing the aperture of the prism or prisms $R = \frac{\lambda}{d\lambda} = a \frac{d\theta}{d\lambda}$ or R varies directly with the aperture.

2. By increasing the number of prisms.

3. By shifting the region of spectrum under observation towards the violet. The resolving power varies inversely as the cube or slightly higher power of the wave length. This will be seen directly when we compute resolving powers, but it follows at once by differentiating Cauchy's form of dispersion formula.

$$\mu = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \dots \text{ or simply}$$

$$\mu = A + \frac{B}{\lambda^2}$$

$$\frac{d\mu}{d\lambda} = -\frac{2B}{\lambda^3}$$

The use of the second method increases the dispersion which is usually not allowable on account of the proportional increase of exposure time entailed. The third method can not be used with a refractor and glass prisms on account of the strong absorption of ultra violet light by the glass of the lenses and prisms. With a reflector and a quartz or ultra-violet glass spectrograph it might be applicable. We are therefore practically limited to the use of a larger prism and consequently larger collimator and camera lenses.

The size of prisms in use in radial velocity work, as previously stated, lies between about 30 and 51mm. Prisms of 51mm. aperture are successfully used in the Yerkes Spectrograph, but Frost's experience as also that of Hale in large spectro-heliograph prisms shows that the limit is nearly reached.

In discussing the necessary conditions for using a wider slit, let us take as an example a comparison between the efficiencies of single-prism spectrographs of 35mm., the aperture of the present instrument, and 51mm. aperture, the latter having been decided upon, after careful consideration, as the aperture of the new instrument. A spectrograph of such aperture, outside of considerations of the homogeneity of larger prisms, is the practical limit as regards size and weight that can be attached to a 15-inch equatorial.

The glass generally used for the prisms is Jena glass 0.102, Dense Silicate Flint, and this was chosen for the spectrographs here. It is very colourless considering its density and dispersion. The indices of refraction of the particular melting from which the present prisms were made, as furnished by the makers, are as follows:—

| Wave Length. | Index of Refraction. |
|--------------|----------------------|
| 00006563 cm | 1.6413 |
| 00005893 cm | 1.6457 |
| 00004862 cm | 1.6603 |

From these values substituted in the Hartmann formula $\mu = \mu_0 + \frac{c}{\lambda - \lambda_0}$ we obtain the values of the three constants μ_0 , c and λ_0 .

$$\lambda_0 = .00002190.$$

$$\mu_0 = 1.61146.$$

$$\log c = 6.115595.$$

From these constants were calculated for a number of wave lengths μ and $\frac{d\mu}{d\lambda}$. From $\frac{d\mu}{d\lambda}$, R was obtained for prisms of 35 and 51mm. aperture, and of refracting angle $63^\circ 50'$, this being the angle required to deviate the ray at minimum, $\lambda 4415.60^\circ$. The formulæ used were previously derived and are:

$$\frac{d\mu}{d\lambda} = - \frac{c}{(\lambda - \lambda_0)^2},$$

$$R = t \frac{d\mu}{d\lambda} \text{ where } t = 2 \alpha \sec \frac{A + \theta}{2} \sin \frac{A}{2}.$$

| Wave Length. | μ | $\frac{d\mu}{d\lambda}$ | R Prism 35 mm. | R Prism 51 mm. |
|--------------|--------|-------------------------|---------------------|---------------------|
| 4862 | 1.6603 | 1829 | 14420 | 21010 |
| 4550 | 1.6667 | 2543 | 18470 | 26910 |
| 4415 | 1.6701 | 2636 | 20780 | 30280 |
| 4341 | 1.6721 | 2822 | 22250 | 32420 |
| 4102 | 1.6796 | 3490 | 27520 | 40100 |
| 4000 | 1.6833 | 3983 | 31400 | 45750 |
| 3970 | 1.6848 | 4119 | 32380 | 47180 |

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The resolving power for the two apertures obtained, the purity of spectrum for different slit widths is readily calculated from $P = \frac{\lambda}{\alpha \psi + \lambda} \cdot R$, ψ in this case, being $\frac{1}{2}$ or .0667. The results are given in the following table for the wave length 4341 or H_γ , this being the usual central ray.

PURITY OF SPECTRUM.

| Slit Width. | Prism 35 mm. | Prism 51 mm. |
|-------------|--------------|--------------|
| 0.025 | 4596 | 6697 |
| .040 | 3114 | 4537 |
| .051 | 2518 | 3670 |
| .063 | 2084 | 3036 |
| .076 | 1755 | 2588 |

These figures show that with the larger prism the slit may be made 50 per cent wider and still have practically the same purity of spectrum, and consequently the same accuracy of velocity determinations.

The slit transmission table previously given showed that an increase in slit width of 50 per cent when below 0.076mm. increased the quantity of star light transmitted by nearly 50 per cent; consequently, other conditions being equal, half as many more spectra could be made in a given time. But an increase in the size of the prism means also an increase in the quantity of light absorbed by the glass of the prism, although the amount reflected will be the same. We can obtain an accurate knowledge of the quantity of light absorbed in the two prisms of O. 102 glass from Vogel's experiments (Astrophysical Journal, V., p. 75), who showed that H_γ light transmitted through 100mm. of O. 102 glass suffered absorption of about 47 per cent. The absorption for prisms of 35 and 51mm. aperture, average length of path 39 and 57mm. respectively,

may be readily calculated by the formula $I_1 = I_0 K^{\frac{x}{a}}$, where x is thickness of glass for which absorption is required, a is thickness for which percentage transmitted is K , I_0 intensity of incident, I_1 of transmitted beam. We obtain for prism of 35mm. aperture 78 per cent, of 51mm. aperture 71 per cent transmission. If 100 be intensity of incident pencil for small prism, then 150 will be intensity of pencil giving equal purity with large prism. After transmission intensities will be 78 and $150 \times .71$ or 106.5, respectively, and the required exposures will be inversely proportional or as 3 to 4, a very considerable gain. Even when the slight additional absorption in the thicker camera and collimator lenses is considered a substantial saving of time will result by the use of the larger prism.

We have tacitly assumed in the foregoing discussion that a decrease of purity entails loss of accuracy in the velocity values. This is undoubtedly true for complex spectra such as those given by solar or allied type stars, spectra in which are hundreds of lines and in which every decrease in purity means increased uncertainty in the wave lengths of the more complex blends of lines thereby produced. In the case of early-type stars, however, such as those of the hydrogen or helium groups, where there are only few lines, and these single, there can be no trouble with blends, and the question of the purity of the spectrum has not so much weight. On such grounds there would be no material advantage in using the larger aperture. However, a consideration of the second effect produced by widening the slit—the increased diffuseness of the spectral lines—will show a similar advantage for the larger aperture even where purity does not come into question.

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'This may be best shown, as before, by considering a special case and we may take the same example with advantage. The present single-prism spectrograph has a collimator objective of 35mm. aperture and 35 x 15 or 525mm. focus. The camera has a focus of 525mm., and therefore the image of the slit on the plate will be of the same size, and the minimum width of line will be the width of the slit. The new spectrograph will have a collimator of 51mm. aperture and 51 x 15 or 765mm. focus. The camera will be of about 455mm. focus. Hence the image of the slit on the plate will be diminished in the proportion of 455 to 765 or about $\frac{3}{5}$. If the camera were of the same focus as the one now in use, 525mm., the image of the slit would be diminished to about $\frac{2}{3}$. Hence the slit can be made in the one case $\frac{3}{5}$, in the other $\frac{2}{3}$, the width with the present spectrograph, and have the lines of the same width, and consequently equally accurately measurable. The gain in efficiency is thus about equal under the latter consideration and that of the maintenance of equal purity, and we may therefore consider that a decided advantage may be obtained in stars of all types by increasing the aperture of the prism. Such conclusions are, of course, subject always to the test of actual use under similar external conditions before they can be accepted as final.

'However, some experiments that I made here last winter on the effect of widening the slit upon the accuracy of velocity determinations* substantiate the above conclusion, and I will therefore give a short summary of some of the results reached. As previously stated, when the slit is widened, the purity is diminished and the lines become broader and more diffuse. To simplify the investigation, the question of the effect of purity was eliminated by choosing a star, β Orionis, for the test whose lines are single and moderately sharp. There remains, then, only the question of the effect of the increasing breadth and diffuseness of the lines on the accuracy of the measures. Evidently such a question can only be settled by making and measuring a number of spectra at each slit width. Six plates were made for each slit width 0.025, 0.038, 0.051, 0.076mm. for two dispersions, (a) single-prism 525mm. camera, (b) three-prism 525mm. camera and six each at slit widths 0.025, 0.051 and 0.076mm. for a dispersion of three prisms and camera of 275mm. focus. In all 66 plates were made, of which I have to thank Mr. Harper for measuring 18 and thus lightening the considerable labour involved. Owing to the different dispersions, different lines were measured in the three sets, but as the main dependence can be placed on the three lines $Mg \lambda 4481.400$, $He \lambda 4471.676$, $H\gamma 4340.634$, the results from these three lines only are given. Computations using all the star lines measured were also performed without, however, changing the conclusions reached.

'There are evidently two kinds of error to be considered, accidental and systematic. Under the first will be considered the accidental errors of the setting of the microscope wire on the individual lines in a plate, resulting in a mean velocity for that plate differing from the true velocity in a greater or less degree depending upon the quality of the lines. The systematic error of a plate is the displacement of the star lines as a whole with respect to the comparison lines. This may be due, as previously stated, to one or more of several causes—change of temperature, flexure, faulty adjustment or aberrations in the optical train, &c. As the lines are in general equally affected, such displacement will not be apparent in the measure of a single plate. It is only by comparing the velocities of a number of plates of a star of constant velocity that such an error can be detected.

'To compare the accidental errors for the different slit widths it will be necessary, to prevent systematic displacements from affecting the result, to treat the measures for each of the six plates for one slit width separately, to obtain the residuals from the mean velocity of each plate and finally the probable error of measurement of an average star line from these residuals. Some idea of the relative magnitude of the sys-

* Since published in the *Astrophysical Journal*, Vol. XXVIII, p. 259.

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tematic errors may be obtained by treating the velocities from each of the six plates. However, this result will not be that due to systematic error only, as the velocity from each plate will also be affected by accidental errors. The results of the measures and computations are given below:—

PROBABLE ERRORS.

| Dispersion. | Slit Width. | Accidental Prob. Error, Average Line. | Systematic Prob. Error, Single Plate. |
|--------------------------|-------------|---|--|
| Single Prism | 0.025 | ± 4.5 km. | ± 1.7 km. |
| | .038 | 2.4 | 2.7 |
| 525 mm. Camera | .051 | 2.3 | 3.0 |
| | .076 | 4.3 | 7.7 |
| Three Prisms | 0.025 | ± 2.3 | ± 1.5 |
| | .038 | 2.1 | 1.3 |
| 525 mm. Camera | .051 | 2.5 | 0.7 |
| | .076 | 2.1 | 0.9 |
| Three Prisms | 0.025 | ± 2.9 | ± 2.1 |
| | .051 | 2.9 | 3.0 |
| 275 mm. Camera | .076 | 3.8 | 2.9 |

These results were to a considerable extent unexpected. The great difference in the apparent quality for measurement of the spectra made with slit 0.025 and 0.076mm., especially with the single-prism, would lead one to expect a marked increase in the errors of setting, but this is not very distinctly shown, not at all in the higher dispersion. The systematic errors, however, are very markedly increased in single-prism plates, so much so as to prohibit the use of slits wider than 0.051mm. In a higher dispersion spectroscope this increase has disappeared, and, so far as the rather small number of plates shows, it is slightly more accurate in the case of dispersion (b) to use slits 0.051 and 0.076mm. than slits 0.025 and 0.038mm. It is evident that these results corroborate the conclusions previously reached, by showing that increase in resolving power removes or diminishes the loss of accuracy when the slit is widened. Consequently, with the 50 per cent greater resolving power and the 60 per cent greater ratio of collimator to camera focus, it is probable that the slit-width may be increased 50 per cent without affecting the accuracy of the results and with a corresponding increase in the output.

Mechanical Design.

The question of the most favourable dimensions of the optical parts having been discussed, there remains the mechanical structure connecting these parts into one stable whole. Owing to the attachment of the instrument to a moving telescope and the consequent varying direction of gravity on the parts, the prevention of flexure is one of the most difficult of the problems to be overcome, and this is especially the case where the instrument is to be attached to a telescope of moderate size, where its weight can not exceed a certain small limit. The weight of our spectrograph complete with temperature case, attaching truss, &c., can not much exceed 100 lbs., and the problem is consequently a much more difficult one than in the case of the Yerkes equipment, for example, where the spectrograph weighs about 500 lbs. Most of the early and some of the recent spectrographs have lacked sufficient stiffness and stability to prevent line displacements due to flexure of the parts. A displacement of the camera and plate of only one one-thousandth of an inch is equivalent in a single-prism spectrograph to a velocity of about 50km. per second. It is evidently a difficult

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matter in the extended form of a single-prism instrument to reduce this flexure to an inappreciable amount. No material is perfectly rigid and when we consider that even its own weight deforms the strongest material available, the difficulty of the problem will be realized.

‘Until very recently all spectrographs were attached to and overhung the end plate of the telescope and thus, like a beam fixed at one end, were subjected to the maximum amount of flexure. An improvement in the principle of attachment was applied at the Lick Observatory recently, in which the spectrograph proper is made self-contained and is held in an independent cradle at two points of support. It is thus like a beam supported at both ends and the flexure is thereby much reduced.

‘The original spectroscope belonging to the Observatory was by Brashear of an adjustable universal type and was not, for this very reason, suitable for radial velocity determinations. Braces were added to stiffen the frame as much as possible, but it could not be freed from flexure. Many of the results obtained were uncertain and its use was discontinued as soon as a new combined one and three-prism spectrograph, designed by myself and very satisfactorily constructed by Mr. Mackey in the Observatory workshop, was completed.

‘This instrument, whose general form is readily obtained from the figures, page 78 in my report to the Chief Astronomer for 1906-7, has many original features, has given excellent satisfaction and produced reliable results. It is, as will be noticed, a form of the first class mentioned attached only to the end plate of the telescope. It was designed and partly constructed before anything was learned of the new type. Moreover it was desired for the sake of economy of time and money to combine single and three-prism instruments in one (since found by experience to be a mistake), and this could not be advantageously effected in the new form.

‘The form of truss designed has some advantages over previous instruments, and has probably less flexure than any other of the same type and weight. The main difference lies in the close grouping of the triangular truss at the lower end and the addition of the substantial diagonal brace, which serves the two purposes of stiffening the outer end of the prism box and lower end of the camera when used in three-prism work, and of tying the outer end of the camera when used with a single prism. The maximum flexure of the three-prism instrument is equivalent to 1.8km. only, while the maximum flexure of the modern Bonn three-prism instrument, the only one for which data have been published, is about 70km. For an hour’s exposure with the Bonn instrument there is a flexure of 7km., while a similar exposure with both single and three-prism forms here shows no appreciable flexure. The maximum flexure with our single prism is much greater, about 100km., equivalent to a linear displacement of about $\frac{1}{400}$ inch. This great difference in the two forms is due to two causes. First, to the threefold greater kilometre value for the same linear displacement. Second, to the much more extended form of the single-prism instrument. Calculations have shown that the amount of flexure is nearly that caused by the actual extension and compression of the truss members due to their own weight, and consequently it can not be avoided or much reduced in this form of instrument. However, the flexure occurring during a two hour’s exposure is only slight except at such great hour angles as are rarely used.

‘Both forms of instrument are frequently required on the same night, for stars of varying brightness and type. The time lost in making the change from single to three prism or vice versa, and the uncertainty in the temperature conditions prevailing after the change, close temperature regulation being equally as important, perhaps more important than avoidance of moderate flexure, were considerations leading to the decision, which had the approval of Dr. King, to design and construct a separate single-prism spectrograph, with separate temperature control and attaching stand, so that the change could be made in a minute or two, and without disturbance of temperature.

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'Besides using a larger prism for the reasons fully entered into above, the opportunity was taken of changing the mode of attachment to the telescope. Curtiss, of Ann Arbor, designed a form of single-prism instrument modelled after the Lick pattern, which has two points of support, one near the slit and the other near the base of the prism. The spectrograph proper consists of a triangular brass box with angles of about 120° , 30° , 30° . The prism is at the obtuse and the slit and camera at the acute angles of the triangle. The camera end hangs out unsupported and flexure will still occur though in a much diminished degree.

'The form I have designed and am now having constructed in the workshop follows that of Curtiss in that it is of the box form, but the design and construction of the box and the method of attachment to the telescope are different. The box is made of hard cast-steel plates (saw steel) much stiffer than brass, is rigidly braced and cross braced, and is provided with three points of support in a cradle of T iron attached to the end plate of the telescope. Two of the points are similarly situated to those of Curtiss, while the third acts near the camera end. The two first are attached by a kind of universal joint, so that no strain can be induced in the box by any bending of the cradle. The third support, near the camera, consists of a pair of counterbalancing levers, one on each side of the box, arranged to equalize the pressure on the three supports in any position of the telescope without it being possible to ever induce any strain in the box itself. By this means it is believed that no measurable or even noticeable flexure will occur.

'A simple triangular box of this form without projections of any kind is much more readily adapted for temperature regulation than the complicated shape of the regular truss form. Moreover, any stratification in the temperature case is much less likely to occur, and if it does, can not do nearly so much harm as if it were acting on only one member of the truss. A further improvement will be the introduction of a non-conducting material, such as vulcanized fibre in the supporting arms between the cradle and the box, so that heat will not be conducted away at these points and unequal temperature and possible distortions take place.

'In the present spectrograph, conduction through the arms of the truss is so great as to cause a gradual drop of the temperature in the prism box, as the outside temperature falls, of about 0.1°C . every one or two hours. The distance between the spectrograph box, which will be entirely covered with thick felt, and the inside of the felt-lined outer case will be uniform, the heating wires will be uniformly distributed, and consequently little difficulty with inequalities of temperature should result.

'Although until the instrument is completed and tested, no definite statement can be made, I have little doubt that the new spectrograph will be a considerable improvement over the present or any existing single-prism instrument.'

THE NEW SINGLE-PRISM SPECTROGRAPH.

The Optical Parts.—After the dimensions of the optical parts of the new instrument had been determined as above they were ordered from the J. A. Brashear Co., in the early part of 1908.

Some correspondence was carried on in regard to the 'Isokumatic' Collimator objective in reference to the yellowish colour of the middle component. It was, however, decided to use it in preference to the less absorbing ordinary objective, on account of the flatter colour curve given by the former. Consequently an 'Isokumatic' of 51mm. (2 inches) free aperture and 765mm. focus was ordered and received at the same time as the other optical parts, about the end of last March. Although no direct tests have as yet been made, there is no question of its being a first class objective, as otherwise the good definition now obtained would not be possible. The prism of Jena glass O. 102 had its angle $63^\circ 30'$ computed, so that the central ray for this instrument $\lambda 4325$ had a deviation of 60° . The length of the side of the prism was made 110mm.,

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so as to transmit the full pencil from the collimator, and the height 57mm. in order that any effect produced by pressure or unequal temperature of the supports might be minimized. The prism is a beautiful piece of glass and the tests have shown it to be of first rate optical quality, and fears as to its possible lack of homogeneity groundless.

The camera objective, owing to the excellent performance of the Brashear Single Material in the previous instrument, was chosen of the same type and is of 57mm. aperture, a sufficient margin above 51mm. to transmit the full usable pencil, and 453mm. focus. It was tested soon after being received and, although it gave a flat field, the definition was not as good as that given by the original objective, and a preliminary test showed this to be due to spherical aberration. The objective consists of two widely separated converging elements of very light crown glass, and consequently the resulting positive aberration can only be removed by departure from spherical surfaces. The amount to be removed in the case of the original objective of 45mm. aperture and 525mm. focus was quite within the possibilities of ordinary figuring, but when the aperture ratio is increased to so large an extent as from $f12$ to $f8$, it becomes a much more difficult problem to deal with. In this case it was only after the introduction of a special method and with the great personal skill of Mr. McDowell in figuring, that the aberration was finally removed, and the objective gave practically perfect definition and a widely extended flat field. A full description of the tests, with the plotted fields resulting from different objectives, is given in full in another place.

The Guiding Telescope.—Instead of reflecting the light used for guiding down a tube parallel with the collimator and there further reflecting it to the guiding telescope so placed as to also receive light reflected from the front surface of the prism, the guiding telescope has in this case been placed about 15cm. above the slit, where star light coming from the inclined speculum-metal jaws is reflected by a right-angled prism to a small objective placed at its focal distance along the optical path from the slit. The resultant parallel pencil is then received by the bent guiding telescope shown, Fig. 2, which can be rotated to any convenient direction. Two reflections are hereby avoided, resulting in some saving of light and probably better definition. It had been found in the previous instrument that the method of guiding by light reflected from the front prism surface was never used, and consequently in the new spectrograph this needless complication was omitted. It may be said, however, that the position of the guiding telescope is in some positions of the equatorial, not quite so convenient as if it were lower down.

The Comparison Apparatus.—Experience has shown that in actual work more than one metal is never used as electrode, and consequently the rotating wheel with four sets of electrodes used previously has been omitted here, and one pair of adjustable electrodes of the alloy of iron and vanadium, whose spectrum is exclusively used for comparison, has been substituted. These terminals are mounted on a brass plate which swivels on two points attached to the top of the guiding telescope, and when not in use is simply turned back upon the latter, thus leaving the star light unobstructed. Directly below the terminals in the optical axis is screwed the short tube shown, in the upper end of which is a piece of ground glass and in the lower a small condensing lens with an angular aperture twice that of the collimator. Both of these are adjustable and ensure in every case a uniform pencil of spark light incident upon the collimator objective and prism.

Slit and Slit Diaphragms.—The slit is of the Huggins type of reflecting slit, with polished speculum metal jaws inclined at an angle of $3\frac{1}{2}^{\circ}$, so that the reflected pencil of star light and consequently the prism which intercepts it is entirely out of the way of the direct pencil. One jaw is fixed and the other movable micrometrically, a single division representing .001 inch (.025mm.). The slit has a tangent screw slow motion to enable it to be placed exactly parallel to the refracting edge of the prism, and is very

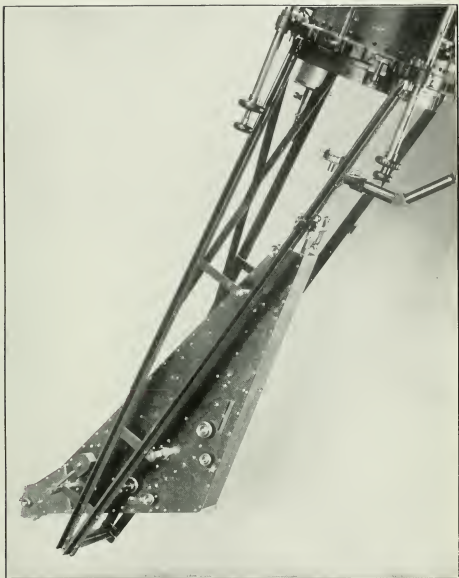


FIG. 2—New Single-Prism Spectrograph.



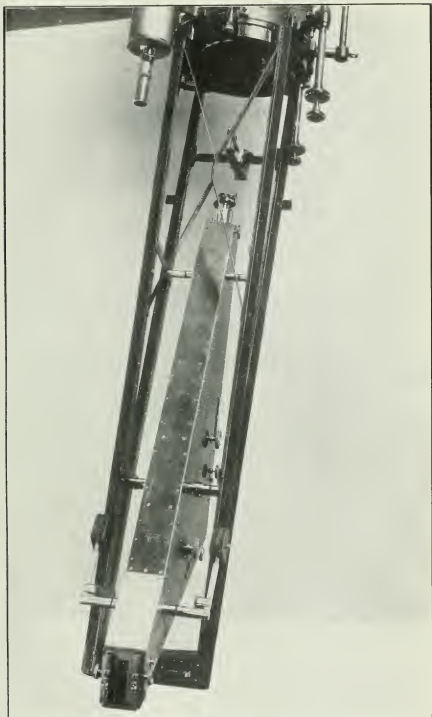


FIG. 3—New Single-Prism Spectrograph.



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rigidly attached to the end of the heavy collimator tube. To the end of this tube is also screwed the attachment holding the sliding diaphragms, which serve to limit the star and comparison spectra. Rectangular openings of the proper width, in this case a single opening 0.4mm. for star spectrum and two openings 1.5mm. separated by a tongue 0.45mm. for comparison spectrum, are placed directly opposite one another on a plate which is moved by means of a knurled wheel transversely between stops across the slit. To expose the spark spectrum all that is necessary is to turn down the spark apparatus, turn the knurled wheel above mentioned about a quarter turn, and close the switch which controls the current through the step-up transformer used for producing the spark, this switch being on the telescope tube about a foot above the spark apparatus. To change back to star spectrum the operations are reversed, the whole cycle occupying only about ten seconds.

The Mechanical parts.—As outlined above the instrument consists essentially of two parts—1. A rigid, hollow, triangular shaped, steel box containing at the obtuse angle the prism, and at the two acute angles the slit and plate and comprising the spectrograph proper; 2. The T iron frame or cradle attached to the end plate of the telescope, in which the spectrograph proper is flexibly supported, and which serves to keep it collimated without flexure of this support producing any stresses in the box itself.

The Spectrograph Box.—The box consists of two triangular shaped plates made of hard saw steel about 1.7mm. thick forming the sides, while the edges consist of plates of the same material and thickness, 79.4mm. ($3\frac{1}{4}$ inches) wide. In addition to the edges there are a number of internal braces and supports of the same material, well shown in Fig. 4, which gives a good idea of the construction of the box. These braces as well as the edges of the box have pieces of small angle iron securely riveted along both edges, to which the side plates are firmly screwed. These angle irons are not shown in the figure, as the frame was first put together, the angles then riveted on and finally the plates screwed to these angles and to the internal castings, the heads of the screws being shown on the side of the box in Fig. 2. It was constructed in this manner to prevent as far as possible any internal stresses in the frame of the box. In addition there are iron castings *A, B, C, D, E, F*, Fig. 4, planed to exactly the same width as the edges and braces. *A*, may be called the main casting, having a hole bored through the centre through which the principal supporting shaft passes. The two legs projecting from the triangular part are bored out to fit the collimator and camera tubes. The casting, *D*, is also bored out for the collimator tube and forms the end plate of the box, while the casting, *F*, is bored out to carry the upper end of the camera tube. *C*, and, *E*, have clearance around them and do not touch the collimator tube, the upper support being attached to the centre of *C*. The part, *B*, has the third supporting shaft screwed into the centre of each side, and also forms the connection between the box proper and the camera end. The latter is made separate, so that camera objectives of different focal lengths may be used if desired.

The prism is mounted in a separate cast-iron cell, but is prevented from touching the metal at any point by facings of hard rubber about 3mm. thick, and is kept in its adjusted position by hard rubber stops. It is held firmly in this position in the cell by the gentle pressure produced by three small clamp screws passing through the top of the cell and bearing upon one of the facings of hard rubber 3mm. thick, above mentioned, resting on top of the prism. The base of the cell is surfaced flat, and rests in its compartment on one of the side plates, to which it is rigidly attached by five screws passing through slotted holes to permit of adjustment for minimum deviation.

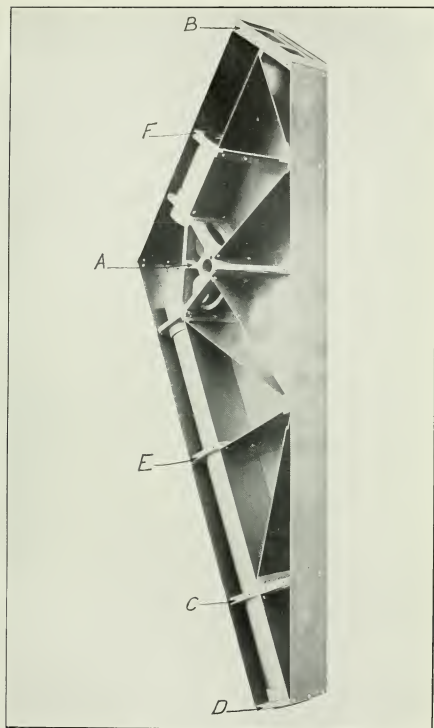
Collimator and camera tubes are provided with racks and pinions for adjustment, their position being read on millimetre scales, the one attached to the camera being provided with a vernier, reading to tenths of a millimetre. The collimator tube is provided with two clamp screws, one at the top and one at the bottom bearing, while

the camera tube has a single clamp screw at the front end. The pinion and clamp wheels and the scales are well shown in Figs. 2 and 3. The camera attachment, whose form and construction can be fairly well obtained from Figs. 2 and 3, is built in box form of the same material, and is firmly screwed to the casting, *B*, Fig. 4, it and the spectrograph box thus forming what is to all intents and purposes one continuous piece. Between the sides of the camera box, swivels the plate holder attachment which is quite similar in form to the one used with the other spectrograph. It consists essentially of a semi-cylinder 79.4mm. long, 101.6mm. diameter, pivoted along its axis between the sides of the box to permit a wide range in plate inclination. This cylinder is constructed from a section cut from a piece of 4-inch brass tubing, on the ends of which pieces of heavy brass plate are screwed and soldered, and on the plane of section is fastened the brass camera back provided with screws for clamping the holders firmly in place. The plate holder carrier has solidly constructed ways permitting lateral movement of about 15mm., enabling a number of narrow spectra to be made side by side on the same plate if desired. The axis on which the camera back rotates is provided with knurled clamping wheels, while other screws moving in concentric slots enable adjustment and firm clamping to be effected in any desired position, read off on graduations on the cylinder.

As will readily be seen from its design and construction and from the character of the material from which it is made, this spectrograph is exceedingly rigid and the flexure produced by changes of position, however supported, would be very small. This flexure, however, is reduced to a vanishingly small quantity by the new supporting system used in this instrument. The self-contained spectrograph box is, as has been indicated above, supported flexibly on three points in the carrying cradle.

The Supporting Cradle.—This truss made of $1\frac{1}{2}$ " T steel is attached at the upper end to a heavy ring casting, which is fastened by the same three swivel bolts used for the other spectrograph to the end plate of the telescope, the mode of attachment being shown in Fig. 3, which with Fig. 4, well shows the form of the truss. It is evident that the only flexure of this truss in a direction parallel to the sides of the spectrograph will be that due to the extension of one arm and compression of the other in each pair, and this will hence be very slight. Owing to the fact that these two pairs of trusses had to be separated about 20cm. at the lower end, to admit the spectrograph with outside temperature case between them, it is evident that flexure in a direction at right angles, parallel to the movement in right ascension, will be greater. This is minimized as much as possible by joining the two ends by a solid webbed casting and by introducing cross braces at the upper end of the truss as shown. At small hour angles, however, which it is desirable for many reasons to use as far as possible, the component of the weight in this direction will be very small and the flexure negligible. Even at large hour angles which are sometimes required, the flexure cannot be great. In any case from the method of attaching cradle and box, to be presently described, no flexure of the cradle can induce any stresses in the box and the only effect of such flexure will be to slightly alter the axis of collimation of the spectrograph. This can not, however, induce any displacement of the spectral lines, not only on account of its relatively small magnitude but also because it can occur practically only parallel to the spectrum lines and to the refracting edge of the prism, which will have no effect on the position of the line.

The principal and central support and connection between cradle and box consists of a shaft 1 inch (25.4mm.) diameter passing through the hole in the main casting. This shaft is left the full size of the hole only for about 2mm. at the centre, so that the box is free to swivel in every direction around the centre to the extent of 2 or 3 degrees. This swivelling motion is, however, limited, by projecting points on the shaft at the ends of the hole, to one parallel to the motion in right ascension and to the slit, rotation around the axis of collimation being prevented. Consequently any flexure of the cradle can not induce any distorting stress in the box.



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The upper supporting shaft has a transverse hole in the centre through which a pin screwed into casting *C* passes, thus allowing longitudinal motion parallel to the axis of collimation as well as swivelling motion in every direction.

The third point of support consists of shafts rigidly screwed into the centre of each side of casting, *B*. A second short shaft at each side carried by plates screwed to the cradle, as shown (Figs. 2 and 3), is placed about 2.5cm. from the first in a direction which, if produced would nearly pass through the centre of mass of the box. A lever attached to these two shafts at each side in such a way as to allow more than sufficient motion without binding, carries a counterbalancing weight, the combined resultant upward thrust of the two on the box being computed to equal the proportional part of the weight that should be carried by this support.

The box is hence carried equally on the three supports without any possibility of distortional stresses occurring in it due to flexure of the cradle, the only effect of such flexure being to slightly change the axis of collimation, which at the utmost can only induce displacements of the second order in the position of the spectral lines.

Temperature Control.—Every precaution having been taken, successfully as will be seen later on, against flexure, there remains, as the other main cause of systematic displacements possibly more dangerous than flexure, displacement due to changes of temperature in the optical and mechanical parts of the instrument. The changes in temperature between day and night or even between evening and morning at Ottawa are considerable, averaging about 8°C. for the former and 6° for the latter. In many cases the temperature in the dome becomes 10°C. lower than that in the temperature case, rendering satisfactory maintenance of constant temperature in the case a difficult matter.

As mentioned in the two previous reports, such difficulty was experienced and the temperature in the prism box dropped gradually about 0.1°C. per hour as the temperature in the dome became lower. When practically the whole of the inside of the case was covered with the heating coils this drop was not so great, but was not entirely overcome. It was believed to be due to the conduction of the heat through the metal parts of the attaching truss, the collimator tube, &c., exposed to the outside air and that, although the temperature inside the case undoubtedly remained nearly constant, the temperature inside the prism box would diminish with the lowering of the outside temperature owing to the greater loss of heat through the exposed supports.

To overcome this as far as possible in the new instrument all of the shafts attaching the box to the cradle were cut at points about 3cm. from the box, just inside the outer case, were bored out and threaded, and a piece of vulcanized fibre separating the ends about 7mm. screwed in. This fibre, seen dark on the shafts in Fig. 3, is a poor conductor of heat, prevents direct metallic conduction from the box inside the temperature case to the cradle outside, and the only part of the spectrograph exposed is the slit head. The temperature inside the outer case is automatically controlled by a pair of electric contact thermometers placed not, as in the previous instrument, one on each side of the prism box, but one in the front near the upper end and one at the back near the camera.

Each of these thermometers controls the heating coils in the corresponding half of the outer case. It was hoped by thus arranging the thermometers and coils to keep the temperature over the whole interior of the case more nearly uniform than previously. These thermometers act in exactly the same way as in the former instrument described in the 1907 report. When the temperature in the case rises the mercury in the open capillary makes contact with an adjustable platinum wire and the resulting battery current attracts the armature of a relay, thus breaking the heating circuit; similarly when the temperature falls the mercury recedes from the platinum terminal, the relay armature is released and current is turned on the heating coils. In practice the regulation is very good, current in the coils as indicated by pilot lamps being turned on and off every few seconds. To smooth down any remaining irregu-

larities the whole exterior of the spectrograph box is covered with a layer of half-inch thick felt, small hinged doors being made over the indexes and scales of collimator and camera.

The temperature case is in this instrument constructed of wood chiefly on account of its greater ease of construction, of its greater heat insulating power, and of the smaller danger of short circuits in the heating coils over one made of aluminum. Moreover, owing to the simple form of the spectrograph, a wooden case can easily be made amply strong. This case is made of $\frac{1}{4}$ -inch thick pine, lined inside with felt about $\frac{3}{8}$ -inch thick and is divided into three sections, the line of junction of the body of the case necessarily following the supporting shafts. The third section, which was necessary for constructional reasons, is a small box-shaped piece at the camera end. All joints between the sections and the joints around the doors in the case, necessary for the adjustment and clamping of collimator and camera and of the contact wires in the thermometers, are carefully padded with felt to be air-tight. This case, which is shown in Fig. 5, is attached securely to the supporting cradle and does not touch the spectrograph proper, the openings around the end of the collimator tube and the supporting shafts being made large enough for free clearance and at the same time heat-tight by washers of felt.

On the felt lining on the inside of this case is stretched about 1,200 feet No. 28 single silk covered German silver wire, arranged in four circuits of 300 feet each, two of these circuits in multiple are controlled by each of the electrical contact thermometers, each governing the coils in its own section of the case. This wire is distributed as uniformly as possible over the inside of the case, the space between the felt coverings of the case and spectrograph being about 2.5cm. and uniform throughout. By the division of the heating coils into two sections, their uniform distribution, and the uniform space between spectrograph and case, the temperature throughout the case should be maintained nearly uniform and not much trouble with unequal temperature should occur. There is no question that some method of mechanical stirring of the air inside the case would give better results, but the difficulty of additional weight and complication with possible vibration prohibit its use.

The temperature control so far as it has been tested works admirably. There is as before a slight drop in the temperature of the prism box when the external temperature drops rapidly, but that does not last long, and by applying the control in the afternoon, thoroughly ventilating the dome so that considerable of the cooling will have taken place, the temperature remains steady for the night.

Adjustment of the instrument.—After the instrument was completed there were several adjustments to be made before any measurable spectra could be obtained. The first of these was to set the slit at the principal focus of the collimator lens. This was done by Schuster's method of alternate focussing of collimator and observing telescope on the same spectral line, the prism being placed alternately to one side and the other of the position of minimum deviation. This method gives satisfactory results, successive values agreeing within two or three-tenths of a millimetre and the mean of several being taken. The prism was easily set to minimum deviation for the line *Fe*, 4325.9. This particular line was chosen on account of the very irregular results given by the line *H β* in the numerous measures of β Orionis, and the consequent determination to shift the central line towards the violet in the new instrument. The measures above referred to show that more accordant results are obtained with the lines to the violet end of the spectrum than with *H β* , and as resolving power, purity, and linear dispersion are all greater there, this should result in a further increase in accuracy. The camera focus is determined in precisely the same way, as with the previous instrument, by making adjacent spectra through the refracting edge and base half of the prisms, and determining the focus by the continuity of the lines. A slit is cut in the side of the spectrograph box into which a semicircular diaphragm can be

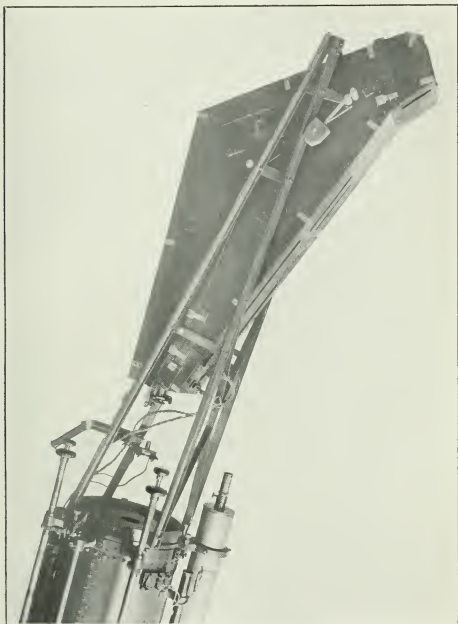


FIG. 5—New Single-Prism Spectrograph, ready for use.

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placed and rotated, so as to occult first one and then the other half of the light pencil. The inclination of the plate, determined of course at the same time, is about $16^{\circ}.5$, the same as with the first objective of this type.

A very curious and at the same time very useful property of the new spectrograph is the constancy of focus of the system for different temperatures. With the two previous instruments, the focal setting increased with increase of temperature about .012mm. per degree centigrade. Between the temperatures of 0° and 20° , all so far tested in the new spectrograph, the camera setting remains unchanged at 27.69 as determined by a number of careful tests. This with the absolute constancy and rigidity of the new instrument is a point of very great value in obtaining accurate results, as it obviates the necessity of testing the focus each time the instrument is used with the possibility of mistakes in the determination of the true setting. It is difficult to explain why there should be this difference, although it is probably due to the fact that the parts connecting camera objective and plate are of steel in the new instrument instead of brass, whose coefficient of expansion is greater. At any rate the combination of brass collimator tube, whose setting is unchanged, and steel camera tube gives settings for camera focus constant at all temperatures so far observed. If the collimator tube had been steel or the camera tube brass, there would have undoubtedly been a change in the setting with change of temperature.

The New Spectrograph in practice.—As stated above the instrument was only completed in the beginning of March, and consequently has not been in use long enough to enable its advantages and disadvantages to be fully determined. There is, however, no question that spectra of better quality for measurement will be obtained with it than with the single-prism form of the previous instrument in which the lines were occasionally, especially with the longer exposures somewhat blurred and diffuse, due to flexure or temperature change or both. As will be seen later, flexure in the new instrument is absent, and owing to its compact form any temperature changes should have much less effect on line displacements. As a matter of fact the temperature regulation is much better with the new instrument and no spectra yet obtained, even with very long exposure, show any trace whatever of diffuseness of the lines. Again, the constancy of the camera focus is another factor tending to better results, as one is always sure of the true focus and no fear of systematic displacements due to poor focus can arise.

Tests have been made similar to those of last year, on the relative freedom from accidental and systematic errors of spectra made at different slit-widths. These show, that on the whole in early type stars with this instrument more accurate values are obtained with a slit about 0.051mm. wide than with slits narrower or wider. The comparative exposures required with the new instrument at slit-width 0.051mm. and the previous single-prism instrument at slit-width 0.038mm., which gives about the maximum accuracy obtainable with it in early type stars, shows an advantage, so far as can be at present determined, of about 25 per cent for the new instrument. To offset this, however, it must be stated that, owing probably to the increased absorption of the larger prism, the intensity of the spectrum at the violet end is appreciably less and for equal intensity of the *K* line, sometimes required, most of the advantage will be lost. In the case of stars in which the extreme violet is not required, however, there is a considerable saving in time and increase in output by the use of the new instrument. This loss in the violet may be due possibly to other causes than absorption of the prism, such as in the guiding or the position of the corrector and form of the colour curve, and if such is the case, and this will be shortly tested, it may to a great extent be overcome.

Careful tests of the flexure of the new instrument have been carried out showing exceedingly satisfactory results. The method of testing was to attach the spectrograph to the telescope, the latter being pointed to the meridian. If the telescope is

turned in declination pointing first to the south and then to the north horizon, it is evident that the spectrograph will have rotated in its own plane through 180° , and there will have been induced in it the maximum possible double flexure. In these two positions spectra were made through a suitable slit diaphragm, the one used for focussing in which the adjacent spectra touch each other being the best, as any displacement of the line between the two exposures will at once be evident. Three sets of exposures of the comparison spark were made on the one plate, by sliding the camera back in its ways between exposures, two for flexure and one with the spectrograph stationary for comparison. Examination of these plates showed no measurable flexure. In some of the lines a very slight displacement could just be detected under high power magnification, but this if due to flexure was quite beyond measurement. As a matter of fact, on the plate being given to Mr. Harper with the request to select from the three the spectrum in which no movement had occurred, he found it impossible to determine which spectra were affected by flexure. As the flexure present during any reasonable exposure can only be a small fraction of that given by the method above described, it is quite evident that the spectra will be absolutely free from any line displacement due to flexure of the spectrograph. It may be of interest to state that flexure tests made of the instrument with the counterbalancing weights removed, and with consequently only two points of support, also showed remarkable freedom from flexure. Although the flexure was slightly more perceptible it was again quite immeasurable, showing the great stability and rigidity of the form of construction adopted.

The previous single-prism spectrograph showed when first constructed a flexure of about $\cdot 035\text{mm.}$, equivalent to a velocity of 70km. per second. When tested at the same time as the new one it was found the flexure had increased to nearly $\cdot 060\text{mm.}$, equivalent to over 100km. per second. As a displacement of the sharp comparison lines equivalent to a velocity of two or three kilometres would be measurable, it is at once seen how much more stable the new instrument is. It is, so far as I can learn, more stable than any other single-prism spectrograph in existence.

The new single-prism instrument, owing to its greater aperture and its design, is necessarily heavier than the three-prism spectrograph and some changes were necessary in the arrangement of the counterweights for balancing. As will be seen from Figs. 2 and 5, the centre of mass is considerably to the left of the optical axis, and in order to properly balance in declination, weight would have to be added to the opposite side of the tube near the object glass. Consequently rods for carrying weights were attached to both north and south sides of the tube near the objective, and the telescope can now be easily placed in good balance whatever attachment is used.

A counterweighted stand for attaching and detaching the new spectrograph, and for carrying it when not in use is provided. It is of quite similar construction to that used with the previous instrument, and allows the spectrograph to be fastened to the telescope in about a minute. With the separate relay box and set of plug contacts, both spectrographs may be maintained at constant temperature, and the change from one prism to three prisms or vice versa made in two or three minutes without disturbance of the temperature regulation in either case.

There will now be given the results of the tests of the new 'Single Material' and the 'Ross Special Homocentric' lenses, and, for completeness, the whole paper, as it will later be published in the *Astrophysical Journal*, will be given.

CAMERA OBJECTIVES FOR SPECTROGRAPHS.

It is well known that the camera objectives in general use in stellar spectrographic work have a very limited field of good definition, not exceeding in general 2° , which covers, in the usual dispersion of three prisms, about 200 tenth-metres. While this is a sufficient range for spectra of the second type, which are rich in lines, it is not sufficient for early-type spectra which may contain only one or two lines in this region, and in which, consequently, the errors of measurement will be high. As practically

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the whole photographic region of the spectrum, H_{β} to K , may be obtained in one exposure with either refractor or reflector, it is evident that a considerable gain in the measurable material in such spectra would be obtained, without increase in exposure time, if a camera lens giving a considerably wider field were available.

Various attempts at the solution of this problem have been made, of which the most successful known to me is that described by Hartmann.* This objective made by Zeiss, known as the 'Chromat,' is constructed of the same material as the prisms, and is composed of two simple meniscus elements, one positive, one negative, separated by a small air space. As there is no chromatic correction the spectra are brought into focus by inclining the plate towards the violet about 16° from the normal to the axis with a dispersion of three prisms. According to Hartmann this objective gives a flat field of 14° . A Zeiss 'Chromat' has been in use in Ottawa for considerably over a year, entirely fulfilling expectations and giving, after slightly increasing the separation of the elements, the whole field used, from H_{β} to H_{δ} (about 8°), almost absolutely flat with excellent definition. There can be no doubt that the field would extend farther if necessary.

Unfortunately, as was learned upon inquiry from Zeiss, this type of objective cannot be successfully made of a larger angular aperture than about $f12$. This was confirmed by the performance of a shorter focus lens of the same type (aperture ratio $f8$) constructed by Brashear which gave inferior definition. More recently, however, Ross Limited, London, have designed and constructed especially to conform to our requirements a lens similar in form to their 'Homocentric,' consisting of four separated elements, but following the principle of the 'Chromat' in being entirely made of the prism material and consequently requiring inclination of the plate to bring the spectrum into focus. This lens, which will be more fully discussed later, gives, at an aperture ratio of $f5.6$, excellent definition and a flat field. The above remarks apply to a dispersion of three prisms for which this type is especially adapted. If it were used with one prism, in addition to the limitations as to aperture, the plate inclination required (about 50°) would be inconvenient and practically inadmissible in radial velocity work.

There are consequently required short-focus objectives giving a flat field with three prisms, and objectives giving a flatter field than the regular triplet with a single prism. This need, together with what had already been accomplished by Hartmann and Zeiss, was laid before the J. A. Brashear Co. who, with their usual willingness, put their best efforts at our disposal and, in collaboration with Prof. Hastings, produced two eminently successful objectives. In both of these the employment of one kind of glass only is followed, although not, as in the 'Chromat,' of the same material as the prisms, and the consequent chromatic differences in focus are overcome by inclining the plate. The objective first produced, to which they have given the name 'Single Material' is composed of two widely separated positive elements of crown glass of the lowest dispersion and is especially adapted for use with one prism, giving exquisite definition and a field flat within 0.1mm. over the whole visible and considerably into the ultra-violet spectrum. The other is similar to the 'Chromat' in form but made of light crown glass, giving also a flat field and good definition with three prisms with a plate inclination of only slightly over half that of the 'Chromat.'

The limiting aperture ratio of the former of these objectives is about $f8$, of the latter $f12$, so that evidently they can not supply the need of short-focus lenses of $f6$ or thereabouts for either single or three-prism work.

The only prospect of success in this respect seemed to lie in some of the modern anastigmat photographic lenses, and a number of different makes were accordingly obtained for trial. The definition of several of these, though good enough for ordinary

* Zeitschrift für Instrumentenkunde, September, 1904.

photographic work, would not stand the critical test of spectrum photography owing probably to some residual spherical aberration. Two, however, the Ross 'Homocentric' and the Zeiss 'Tessar,' gave good definition and the forms of their fields were accordingly determined.

It may not be out of place to give a brief description of the method employed in determining the fields of the ten lenses tested. The dispersion for eight of them was produced by the Ottawa spectrograph, having the following optical constants:—Hastings 'Isokumatic' collimator objective of 35mm. aperture and 525mm. focus; one or three prisms of Jena glass O. 102, angles $63^{\circ} 50'$ each; ray at minimum deviation $\lambda 4415$. Two of the objectives were tested with a new single-prism spectrograph having 'Isokumatic' collimator of 51mm. aperture and 763mm. focus, O. 102 prism of angle $63^{\circ} 30'$, ray at minimum $\lambda 4325$.

The positions of focus in different parts of the field were determined by a modification of Hartmann's method* of extra-focal exposures. By means of a revolvable semi-circular diaphragm behind the collimator lens and an occulting diaphragm in front of the slit, a narrow strip of spectrum, photographed through the half of the prisms near the refracting edge, was placed between and touching two narrow strips made through the base half of the prisms. Evidently, when the plate is in the focus of the camera lens for any particular line in the spectrum, the adjacent portions of this line will be continuous, while, if not in focus, the central section will be displaced to red or violet of the outside sections, the direction and magnitude of this displacement giving a measure of the position of the focal point for the line in question. Two such plates, one inside and one outside the focus, will suffice to determine the form of the field. In order to avoid the labour of measurement and computation and on account of the diffuseness of the lines and consequent inaccuracy of measurement, when the plate is more than a millimetre from the focus, I have generally preferred to make a number of spectra, by the method outlined above, at camera settings about 0.25mm. apart within and without the focus. Five of these have in general sufficed to determine the focal curve and, as the camera back can be moved laterally, they can all be made on one plate, thus allowing ready comparisons. Simple inspection of these spectra under a microscope or even by a hand magnifier enables the focus of any line to be determined to about 0.05mm. by observing at which of two successive spectra the central section has opposite displacements with respect to the outside sections. Interpolation to the above accuracy can then generally be made. This takes only one-tenth the time and is probably equally as accurate as the method of measuring the displacements and computing the distance from focus. I may say that the camera setting in our regular work is always determined in this way, enabling the plate to be certainly placed considerably within 0.1mm. of the true focus.

This method is probably open to the objection that it will not give the true focal point when the system has aberration, but it must be remembered that, to prevent systematic displacements in radial velocity work due to non-uniform illumination of the collimator objective, this method, which determines the focus by the absence of such displacement, is certainly the one that should be used. Moreover, in this case tests at full aperture, so far as the focus can be determined by definition, confirmed the results of the former method, and there is no reason to doubt the accuracy of the focal curves determined.

* *Zeitschrift für Instrumentenkunde*, 24, 1, 1904.

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The following ten lenses, given in the order of procuring and testing, were tested for their curvature of field.

OBJECTIVES TESTED FOR FIELD.

| Number | Objective. | Aperture. | Focal Length. | Tested with dispersion of |
|--------|--------------------------------|-----------|---------------|---------------------------|
| 1... | Brashear Single Material. | 45 | 525 | 1 Prism, 3 Prisms. |
| 2... | Zeiss Chromat. | 45 | 525 | 3 Prisms. |
| 3... | Ross Homocentric. | 40 | 254 | 3 Prisms. |
| 4... | Zeiss Tessar. | 48 | 305 | 3 Prisms. |
| 5... | Brashear Light Crown. | 45 | 525 | 3 Prisms. |
| 6... | " Telescope Flint. | 45 | 525 | 3 Prisms. |
| 7... | " O. 102 ("Chromat").. | 45 | 375 | 3 Prisms. |
| 8... | " Triplet. | 57 | 480 | New 1 Prism, 3 Prisms. |
| 9... | " Single Material. | 57 | 457 | New 1 Prism. |
| 10... | Ross Special Homocentric. | 40 | 254 | 3 Prisms. |

The form of field of each of the lenses is given in the accompanying figures where the horizontal lines represent differences of focus of one millimetre, the wave length and angular distance from the optical axis are shown by the vertical lines, and the diameters of the circles representing the observed points are 0.2mm. Wherever the curves are not horizontal indicates that the inclination of the plate holder required changing slightly, but this of course has no effect on the form of the field. In order to group the curves according to the type and purpose of the objectives, the order given in the above table has been changed and those of longer focus used with a dispersion of three prisms will be first considered (Fig. 6).

Brashear Single Material (No. 1.)

This consists of two simple converging lenses, the front double convex, the rear convex meniscus, of crown glass of lowest index, separated by nearly one-third the focal length. As will be seen later, this objective gives a beautiful field with one prism, but is strongly concave towards the lens with three prisms, with about the same curvature of field as the regular Hastings Triplet. The inclination of the plate towards the violet is slightly over 5°. Allowing deviation from focus of 0.1mm., slightly over 2° of field is usable.

Zeiss Chromat (No. 2.)

This consists of two strongly curved meniscus elements of Jena glass O. 102, the front diverging, the rear converging and of about half the focus of the combination. When received it gave a field convex towards the lens as shown in the upper curve. When the separation between the elements was increased from 2.25 to 4.5mm. the field became almost absolutely flat over the whole 8°, giving at the same time excellent definition. Inclination of the plate towards the violet about 16°.

Brashear Light Crown (No. 5.)

This is a lens of the same form as the 'Chromat' except that it is made of light crown glass. With the original separation the field was concave but became flat on decreasing the separation from 4.8 to 3.2mm. This change in separation resulted in loss of defining power. The objective was re-figured at the new separation and gave good definition and field flat over practically the whole range. Inclination of plate to the violet about 9°.

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Brashear Telescope Flint (No. 6).

An objective similar to the previous one only made of telescope flint glass. The field was originally convex but became flat on increasing the separation from 4.8 to 7.9mm. Refiguring did not give so much improvement as in the light crown objective. Field is now practically flat. Inclination of plate to the violet is about 13.5° .

Brashear Triplet (Hastings) (No. 8).

This is a lens of the same type as used in the Mills, Bruce and Lowell spectrographs. The field is, as shown, strongly concave towards the objective with a usable portion, allowing deviation of 0.1mm., of about 2.5° . The definition at the centre of the field is about the same as in the 'Chromat,' but towards the margins even when in focus is much inferior.

All the above objectives are of relatively long focus, small angular aperture, about $f\ 12$, tested with dispersion of three prisms. Let us now examine the fields given by shorter focus objectives, using the same dispersion (Fig. 7).

Ross Homocentric (No. 3).

This standard photographic objective gives good definition but a strongly concave field. An increase in separation from 59 to 124mm. appears to flatten the field, but at the expense of defining power and the lens is not usable at the increased separation. Useful field is not more than 2° .

Zeiss Tessar (No. 4).

This objective was one of the standard form taken from the stock of Bausch and Lomb. It gives good definition and a field very slightly convex. This convexity is removed by an increase in separation from 41.0 to 41.7mm., but with a slight loss in defining power, so that it is probably preferable to use it at the normal separation. Another lens of the same series, aperture, and focus was tested, giving practically the same field but considerably poorer definition. This is of interest as showing the differences between the performance of two objectives presumably identical and indicates the desirability of specially selecting and testing the lens to be used from a number.

Brashear O. 102 ('Chromat') (No. 7).

This objective of the same type and material as the Zeiss Chromat but of larger angular aperture, gives a field nearly flat with a separation of 6.3mm., but with poor definition even after refiguring. This shows that this type can not be successfully constructed of larger aperture ratio than $f11$, say. Inclination of the plate to the violet about 16° .

Ross Special Homocentric (No. 10).

This objective was, by the kindness of the makers, Messrs. Ross, Limited, especially computed and constructed for us. It has an aperture ratio of $f5.6$, is of practically the same form as their Homocentric, but with all four elements of O. 102 glass. It gives beautiful definition and a field nearly flat, usable over 8° . Change of separation is without appreciable effect on the form of field. Inclination of plate to the violet about 16° .

Two types of objectives of medium and long focus have been tested with a dispersion of one prism (Fig. 8).

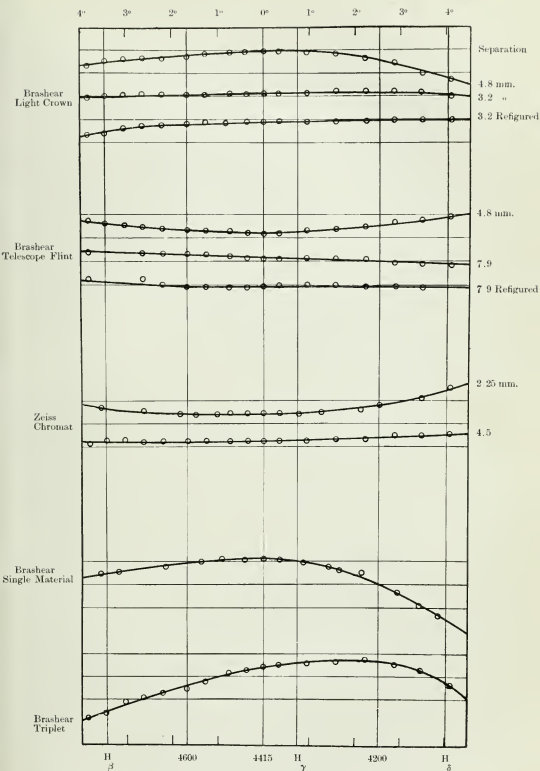


FIG. 6—Long Focus Objectives with three prisms.

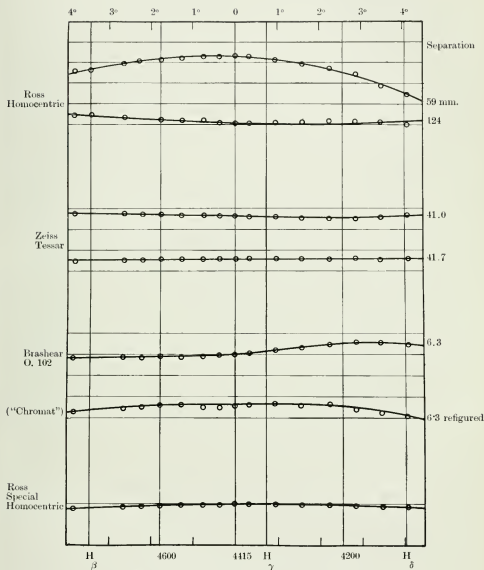


FIG. 7.—Short Focus Objectives with three prisms.

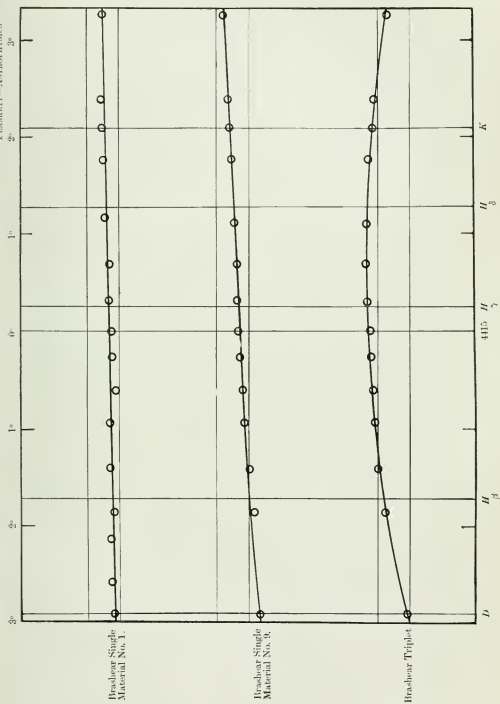


FIG. 8.—Objectives tested with one prism.

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Brashear Single Material (Nos. 1 and 9).

Both of these objectives, whose form was described above, are of the same type, No. 1 of an aperture ratio $f11.5$; No. 9, $f8$. When used with three prisms they give the strongly concave field shown in Fig. 6, but with a single prism the field is almost absolutely flat over the whole range of visible and as far into the ultra-violet spectrum as the prism will transmit. The definition given is excellent and the objectives leave nothing to be desired for single-prism work. The inclination of plate to the violet is about 16° . I am glad to express here my appreciation of the efforts, as well as my admiration for the skill of Mr. McDowell in figuring these objectives. As both components are converging, the only means of removing the positive spherical aberration is by departure from spherical surfaces. While, as Mr. McDowell says, this was comparatively easy for No. 1, of the smaller angular aperture, it taxed even his skill to remove it entirely in the other, and it was only after a second trial and the use of a special device that the objective was finally made perfect.

Brashear Triplet (No. 8).

This, as with three prisms, gives a field concave towards the objective but with considerably less curvature. The usable field is somewhat over 2° . Definition good.

The final results of the investigation may be summarized as follows:—

For a dispersion of three prisms with a camera of fairly long focus two objectives are much superior to the others, the Zeiss 'Chromat' and the Brashear Light Crown. The former gives a flatter field and slightly better definition than the latter, but on the other hand the smaller plate inclination of 8° instead of 16° and the smaller absorption of the Brashear are an advantage. The definition of either of these is fully equal to the regular triplet in the centre of the field and much superior at the margins.

For short-focus lenses with three prisms both the Zeiss 'Tessar' and the Ross 'Special Homocentric' give good definition and flat fields. The Ross can be used of shorter focus than the Tessar, and gives exquisite definition, but the field of the Tessar is flatter and the plate is normal to the axis.

In single-prism work the Brashear 'Single Material' is much superior to the type of Triplet usually employed, both in definition and extent of field and can not be surpassed or even equalled for its purpose.

MEASUREMENT AND REDUCTION OF STELLAR SPECTRA.

With the exception of some plates measured on the spectro-comparator, which will be fully described below, all of the measurements have been made with the Toefer microscope, and reduced by the modified Hartmann method previously described and explained. When the new single-prism spectrograph was brought into use it was found necessary to obtain tables, similar to those previously prepared, for the reduction of the spectrograms.

As before, plates of the comparison spectrum were made at three temperatures, as far separated as the time and season would permit, and these plates were measured.

From these measures the constants of the Hartmann interpolation formula $\lambda - \lambda_0 = \frac{c}{s - s^0}$ were computed, using as the three standards different sets of lines, for the purpose of determining which would give the best agreement over the whole range of spectrum. It was not thought necessary, after the work of Mr. McLean, described in the 1907 report, to use the complete formula,

$$s_1 - s = \left(\lambda - \lambda_0 \right) \alpha,$$

as he showed that with the previous single-prism instruments, the best agreement was given when $\alpha = 1$.

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It was found that standards chosen at the middle and near the ends of the spectrum gave the best agreement on the whole and these, with the measures corresponding and the constants for the three temperatures, are given.

TABLE OF CONSTANTS.

| Temp. C. | 4864.943 | 4341.162 | 3930.450 | s_0 | $\log r$ | λ_0 |
|-------------|----------|----------|----------|----------|-----------|-------------|
| | s_1 | s_2 | s_3 | | | |
| 2.8. | 75.9840 | 50.9383 | 20.5074 | 176.9410 | 5.4249320 | 2229.851 |
| 8.6. | 75.9851 | 50.9168 | 20.4543 | 176.9951 | 5.4250393 | 2230.595 |
| 15.6. | 75.9937 | 50.8696 | 20.3763 | 176.9751 | 5.4248560 | 2231.943 |

Forming the differences between the s^* 's and the \log . of the ratio we have:

| Temp. C. | $s_1 - s_2$ | $s_2 - s_3$ | $s_1 - s_3$ | $\log \frac{s_1 - s_2}{s_1 - s_3}$ |
|-------------|-------------|-------------|-------------|------------------------------------|
| 2.8..... | 25.0457 | 30.4309 | 55.4766 | 9.65462 |
| 8.6..... | 25.0683 | 30.4625 | 55.5308 | 9.65459 |
| 15.6..... | 25.0861 | 30.4933 | 55.5794 | 9.65452 |

The changes in these differences and in the \log . of the ratio are only about half those given with the other single-prism spectrograph. This is undoubtedly due to the fact that the camera setting remains unchanged with change of temperature in the new instrument, and, consequently, only the change in the angular dispersion appears, instead of that due to angular dispersion plus that due to increase in distance of the focal plane from the camera objective.

Averaging up the differences as far as possible, an increase of temperature of 1°C . increases $s_1 - s_2$ by .008 revolution, and diminishes $\log \frac{s_1 - s_2}{s_1 - s_3}$ by .00001.

Forming an arbitrary series with these differences from the last two columns of the previous table, keeping them as close as possible to the observed values and computing 2nd and 3rd columns we have for differences of 10° .

| Temp. C. | $s_1 - s_2$ | $s_2 - s_3$ | $s_1 - s_3$ | $\log \frac{s_1 - s_2}{s_1 - s_3}$ |
|-------------|-------------|-------------|-------------|------------------------------------|
| -10..... | 25.0070 | 30.3675 | 55.3745 | 9.65475 |
| 0..... | 25.0376 | 30.4169 | 55.4545 | 9.65465 |
| +10..... | 25.0681 | 30.4664 | 55.5345 | 9.65455 |
| +20..... | 25.0985 | 30.5160 | 55.6145 | 9.65445 |

Again, taking the arbitrary equidistant values of s_2 for these four temperatures, which make the micrometer reading for the iron line at minimum deviation $\lambda 325.9$

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as near as possible to 50.0000, we obtain the following values for s_1 , s_2 , s_3 and from them the three constants of the formula:—

| Temp. C. | s_1 | s_2 | s_3 | s_0 | log c | λ_c |
|-------------|---------|---------|---------|----------|-----------|-------------|
| -10. | 75.9260 | 50.9190 | 20.5515 | | | |
| 0. | 75.9516 | 50.9200 | 20.5031 | 176.9129 | 5.4250327 | 2229.197 |
| +10. | 75.9891 | 50.9210 | 20.4546 | 176.9736 | 5.4248342 | 2231.163 |
| +20. | 76.0205 | 50.9220 | 20.4060 | 177.0327 | 5.4246277 | 2233.137 |

From these constants were computed the micrometer readings for all the star and comparison lines employed, and in addition the velocities corresponding to one revolution of the micrometer screw for each star line. This latter is obtained by differentiating the dispersion formula and applying Doppler's principle resulting in

$$v = \frac{299860}{\lambda} \cdot \frac{(\lambda - \lambda_0)^2}{c}$$

The velocities per revolution, as compared with those for the original single prism, are given for a few lines below to give some indication of the difference in dispersion.

Velocities per Revolution.

Temperature + 10°C.

| Wave Length. | Old One Prism. | New One Prism. |
|--------------|----------------|----------------|
| 4861.527 | 1454.4 | 1604.5 |
| 4713.308 | 1336.6 | 1473.7 |
| 4549.766 | 1209.0 | 1332.1 |
| 4481.400 | 1156.5 | 1273.9 |
| 4395.286 | 1091.1 | 1201.3 |
| 4340.634 | 1050.1 | 1155.8 |
| 4260.640 | 990.6 | 1089.9 |
| 4202.161 | 947.7 | 1042.3 |
| 4143.928 | 905.4 | 995.4 |
| 4101.890 | 875.2 | 961.9 |
| 4026.352 | 821.5 | 902.4 |
| 3970.177 | 728.1 | 858.3 |
| 3933.825 | 756.0 | 830.9 |

These velocities show that the new instrument has very approximately ten per cent less linear dispersion than the old. This, of course, is due almost entirely to the shorter focus camera lens used, as the prisms are nearly alike and the angular dispersion similar.

The Spectro-comparator.

The Spectro-comparator, which was briefly referred to in my last report, has not been used except on a few plates of β Geminorum more to test the capabilities of the instrument than for the purpose of obtaining definite measures of the velocity of this star. Before giving these measures, however, it may be well to shortly describe the instrument, its principle and the methods of measurement. These have been very fully described by its inventor, Dr. Hartmann, in the publications of the Astrophysical Observatory of Potsdam, Volume XVIII., Part 1, and consequently need not be gone into in great detail here.

The principle of measurement depends upon the direct comparison in a special form of double image microscope of the star spectrum, whose velocity is required with a standard spectrum of the sun, whose velocity at the instant the spectrum was made.

can be readily computed. The difference in the displacements of the star and the sun lines with respect to the same metallic comparison lines on each plate is measured by a micrometer screw, and this linear displacement can be at once converted into kilometres by multiplication by a known or easily computed constant. By adding to this radial velocity that of the sun with respect to the earth, with the proper sign, we obtain the velocity of the star with respect to the earth, and this can be readily reduced to the sun in the well known way.

The instrument of which a photograph is shown in Fig. 9 and diagrams in Figs. 10 and 11 was constructed by Zeiss in a very workmanlike manner. It consists essentially of a table *T*, Fig. 10, which carries at *E*₁ and *E*₂ the standard solar and the star spectrum respectively, and of a single ocular double objective microscope carried above the table on the bracket *R*, Fig. 11, which combines and compares the images of the two spectra.

The table *T*, which as Fig. 11 shows, is inclined at 45° to the horizontal for convenience in measuring, slides at its lower portion on the steel cylinder *Z* 35mm. diameter and at its upper part on the steel bar *J*. It is moved on these bearings over a range of 12cm. by rack and pinion of which the knurled wheel is shown at *K* and is clamped in any position, read off on the scale and vernier *N*, by the clamp screw near *K*. At the upper part of the table a carriage *B*₁ slides transversely in ways, adjustment being made by the screw *G*, while a secondary carriage *A*₁, having a slit 1cm. wide and 12cm. long, through which the star spectrum is illuminated by the plane mirror shown in Fig. 11 is oriented by the tangent screw *D*₂ and the opposing spring *F*₂, so that the spectrum, clamped on it may be placed parallel to the motion of the table *T*. The carriage *B*₁, which carries the standard or fundamental solar spectrum, has an orienting table *A*₁, adjusted by the screw *D*₁ and spring *F*₁, and slides in ways parallel to the motion of the table *T*. It is moved by means of the micrometer screw *S* of 0.5mm. pitch, having a range of movement slightly over 2cm. The head is divided into 100 parts so that the movement of the sun spectrum can be read direct to 0.005mm. and estimated to 0.0005mm.

The double microscope, Fig. 11, by which these two spectra are observed is supported by the bracket *R* on which the arm *R*₁ slides, moved by the screw *H*, the position being read on the scale *W*. The tubes carrying the objectives *O*₁ *O*₂ are attached at a fixed distance from one another to a plate *L*, movable in ways on the arm *R*₁ by the screw *Q*. At the upper ends of the objective tubes, which are provided with rack and pinion movement for focussing, are the prisms *P*₁ *P*₂, which reflect the light from the spectra on *E*₁ and *E*₂ to the compound prism *P*₃ *P*₄. On the hypotenuse of the prism *P*₄ is a surface silvered in the form shown in Fig. 12, and the two prisms are then

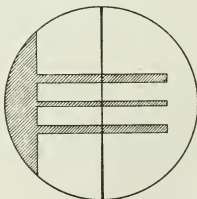


Fig. 12.

cemented together with Canada Balsam. The proper proportioning of the widths of the silver strips enables one to see, on looking through the eyepiece, a narrow strip of

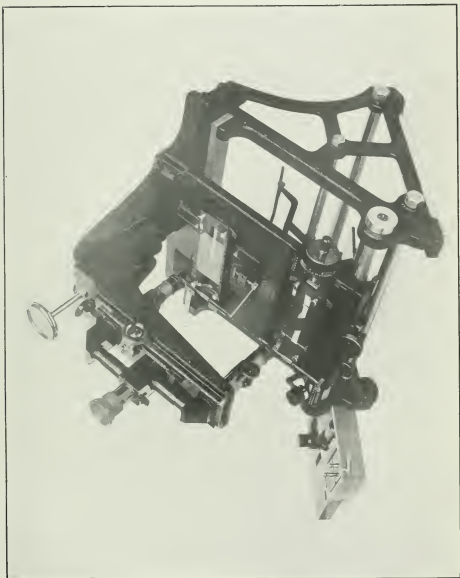


FIG. 9—Spectro-Comparator.

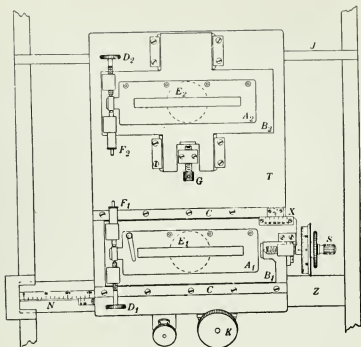


FIG. 10.

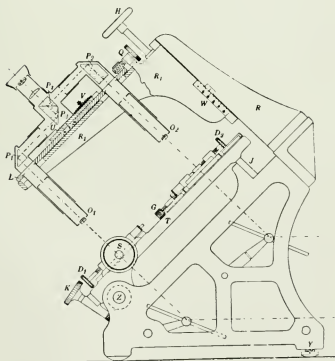


FIG. 11.

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star spectrum between and touching two strips of sun spectrum, and also on either side a narrow strip of the star comparison between and touching strips of sun comparison spectrum. The compound prism $P_1 P_2$, with the eyepiece, is carried on a slide U moved by rack and pinion V , so that the distance between the eyepiece and the objectives and consequently the magnification of the two spectra may be changed at will. This is to enable them, even though of different dispersions, to be made apparently identical in the field and hence readily and accurately comparable.

The adjustment of the spectra on the machine is a comparatively simple matter, only taking a few moments. The standard or fundamental solar spectrum usually made on a lantern or process plate in order to obtain sufficient contrast, is placed on its carriage, and clamped by a pair of spring microscope clamps. The carriage is then moved by the pinion K until the centre of rotation of the orienting arrangement is directly under the microscope 1, which is in this case at the reading 132.3 on the scale N .

The whole microscope system is now moved by the screw Q until the solar spectrum is centrally situated with respect to the central silver strip in the field. By moving the carriage back and forwards the spectrum can be rapidly oriented. The star spectrum may be similarly oriented while it is made central by the screw G . There then remains only to adjust the magnification of the separate spectra, the comparison lines of the two appear coincident in the whole extent of the field of view. By moving the ocular by the rack and pinion V , the magnification of one spectrum is increased and of the other decreased. This will evidently disturb the focus, but this can be easily corrected by adjusting the objectives O_1 and O_2 by their focussing screws seen in Fig. 9. This will again slightly change the magnification and the process may need to be repeated, but a little practice soon enables one to equalize the apparent dispersion very quickly.

Before making any measurements it is necessary to divide the fundamental solar spectrum into regions, indicated by small ink dots, and numbered for identification. These regions are so chosen that there is a slight overlapping of the field in adjacent regions with the magnification to be employed. The dots, which are brought under the wire in the measurement, are placed, as nearly as possible, in the centre of a group of good solar lines and at the same time so that the field includes a number of good comparison lines. The regions selected in a series of good fundamental solar spectra made on May 14, 1908, on Seed process plates are given in the following table. In addition in the third column of the table are given the velocities corresponding to one revolution of the micrometer screw. These velocities were computed from the measurement of lines on the fundamental spectrum by the micrometer screw of the comparator. These linear measurements were used to obtain the constants of the Hartmann formula, and from these constants the velocities corresponding to the wave length of each region were computed.

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CONSTANTS OF FUNDAMENTAL SPECTRA, 1519-1526.

Exposed May 14, 1908.

| No. of Region. | Wave Length. | Vel. per Rev. S. | No. of Region. | Wave Length. | Vel. per Rev. S. |
|----------------|--------------|------------------|----------------|--------------|------------------|
| 1..... | 4867.0 | 582.1 | 14..... | 4374.5 | 364.2 |
| 2..... | 4867.0 | 555.4 | 15..... | 4346.5 | 352.1 |
| 3..... | 4754.0 | 531.9 | 16..... | 4322.8 | 341.8 |
| 4..... | 4769.6 | 512.0 | 17..... | 4298.2 | 331.1 |
| 5..... | 4669.0 | 494.0 | 18..... | 4273.3 | 320.4 |
| 6..... | 4628.7 | 476.0 | 19..... | 4249.9 | 310.4 |
| 7..... | 4590.2 | 459.1 | 20..... | 4226.8 | 300.6 |
| 8..... | 4554.6 | 443.2 | 21..... | 4206.0 | 291.7 |
| 9..... | 4523.9 | 429.7 | 22..... | 4184.3 | 282.1 |
| 10..... | 4492.0 | 415.7 | 23..... | 4157.2 | 271.2 |
| 11..... | 4460.3 | 401.7 | 24..... | 4139.5 | 263.4 |
| 12..... | 4429.6 | 388.3 | 25..... | 4117.8 | 255.7 |
| 13..... | 4402.1 | 376.2 | 26..... | 4099.0 | 246.7 |

$$\text{Log } f = \log. \frac{1}{2 \approx \frac{1}{2}}$$

| Region. | 3 | 4 | 5 | 6 | 7 |
|---------|---------|---------|---------|---------|---------|
| 13..... | | | 1.37646 | 1.42045 | 1.47137 |
| 14..... | | | 1.32312 | 1.36175 | 1.40594 |
| 15..... | | 1.24332 | 1.27409 | 1.30846 | 1.34727 |
| 16..... | 1.17577 | 1.20695 | 1.22877 | 1.25961 | 1.29412 |
| 17..... | 1.13813 | 1.16116 | 1.18647 | 1.21436 | 1.24333 |
| 18..... | 1.10239 | 1.12355 | 1.14671 | 1.17207 | 1.20008 |
| 19..... | 1.06833 | 1.08786 | 1.10914 | 1.13236 | 1.15784 |
| 20..... | 1.03576 | 1.05385 | 1.07349 | 1.09483 | 1.11815 |
| 21..... | 1.00457 | 1.02139 | 1.03958 | 1.05928 | 1.08072 |
| 22..... | 0.97452 | 0.99028 | 1.00710 | 1.02535 | 1.04514 |
| 23..... | 0.94533 | 0.95996 | | | |
| 24..... | 0.91718 | 0.93098 | | | |
| 25..... | 0.88998 | 0.90283 | | | |
| 26..... | 0.86348 | 0.87555 | | | |

The magnification of the two spectra may be varied between about 10 and 40 fold by means of two pairs of objectives and three oculars. Moreover, by suitably varying these the silver strips on the prism may be varied in apparent width to suit star spectra of different widths. It has been found that a magnification of about 20 seems to give better and easier measurements than either higher or lower powers, and it has generally been used, although tests have been made with different powers.

When the plates have been adjusted as described above, the line in the centre of the field is set on the dot towards the red end at which it is deemed advisable the measurement should begin. This is determined by the appearance of the star spectrum and of its comparison lines. It has not been generally taken lower down than No. 5 at wave length $\lambda 4669$, as below that the comparison spectrum is not so good and no gain in accuracy would result. Towards the violet end the measurement is carried until the star spectrum becomes too weak for accurate comparisons, frequently about dot 20, wave length $\lambda 4227$. However, in a well exposed star spectrum the measurement could be extended over the whole range on the plate from $H\beta$ to $H\delta$, although in my opinion nothing would be gained in accuracy by such procedure over that obtained by the use of a less number, say 12 or 15 regions. The measurement proceeds according to a regular scheme of alternation of star and comparison settings,

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so that at each region there are two settings on the star and two on the comparison lines, one by forward and one by backward rotation of the screw in each case. As soon as the measurement is completed, both star and fundamental spectra are reversed on the machine to overcome personality in the settings and the same regions are again measured.

It has been my experience that the most difficult part of the measurement is the determination of the point of coincidence of star and fundamental spectrum. Although with solar type stars of a considerable range in type, there is so little difference in the lines as to cause no trouble, nevertheless there are frequently apparently accidental irregularities in some of the lines in a region which render it difficult to determine the exact point of coincidence. The field extends over a considerable angle, and the eye can only observe at the most two or three lines at a time. These may be brought into the best coincidence, while lines in another part of the field may be better suited by a slightly different setting, and the best average is sometimes troublesome to obtain. These irregularities are chiefly due, I think, to irregular deposition of the silver grains in the comparatively coarse structure of the fast plates, to local distortions of the photographic film, to possibly non-uniform intensity of the star spectrum throughout its width and to other causes of a similar nature rather than to constant differences in the spectrum of star and sun. Such differences can be noted in the case of some lines, but these seem to be few compared with the accidental deviations observed. This difficulty does not exist to so great an extent with regard to the emission lines. Provided the comparison spectra are of nearly the same intensity, coincidences can be easily, quickly, and accurately obtained. The accidental deviations observed in the apparent positions of star lines serve to explain the comparatively high residual sometimes obtained in the direct measurement of good lines in solar type spectra.

After the measurement is completed the reduction of the separate measures to velocities is a simple matter. The difference in the settings for coincidence between emission and absorption spectra, multiplied by the velocity per revolution at the region under consideration gives the velocity at once. These differences are, however, tabulated for both positions of the plate, and the mean of the two for each region multiplied by the velocity factor gives the velocity for the region, while the velocity for the plate is obtained from the mean of the regions.

This considers all the regions as of equal weight, whereas such is not the case. In some parts of the spectrum the lines are more numerous or of better quality, and moreover as the dispersion increases, as we go towards the violet, greater weight should be given. There are then two courses open, to give weights according to the quality of the regions, increasing these as we go towards the violet, or to give weights proportional to the dispersion. The latter method is much simpler, and should give practically the same values as the more complex method and better values than the simple mean. Moreover, Hartmann has developed a very simple method of obtaining the velocity from the differences. If we call the differences with red to right d_1 and with red to left d_2 , then the mean $d = \frac{1}{2} (d_1 + d_2)$, which multiplied by the velocity factor s , gives velocity sd for the region. Its weight is proportional to $\frac{1}{s}$, and hence the

weighted mean velocity can be very simply represented by $\frac{\sum d}{\sum \frac{1}{s}}$. As $d = \frac{1}{2} (d_1 + d_2)$ we

can avoid taking the means of the differences by changing it to $\frac{\sum d_1 + \sum d_2}{2 \sum \frac{1}{s}}$. If we take

the velocity values per revolution of the fundamental spectrum and form the expressions $\log \left(\frac{1}{2 \sum \frac{1}{s}} \right)$ between all the regions which are likely to be used, the only pro-

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cedure necessary to obtain the weighted mean velocity is to add all the differences together and add to the logarithm of the sum the tabulated value of the above expression. To the velocity of which this sum is the logarithm, must be added the computed radial velocity of the sun when the spectrum was made, and we have the radial velocity of the star with respect to the earth, which reduced for diurnal and annual motion will give us the velocity with respect to the sun.

As mentioned previously, only a few plates of β Geminorum made with the three-prism spectrograph have been measured, principally as a test of the capabilities of the instrument. It can practically be used only with spectra of the second and third classes, those with numerous well defined lines, allied to the spectrum of the sun. Our single-prism spectrograph has been almost entirely employed on stars of early type spectra, which can not be economically or accurately measured with the spectro-comparator. However, work on some solar type spectroscopic binaries with a short-focus camera on the three-prism spectrograph is about to start, and for the measurement of such spectra the comparator is especially suited.

One spectrum of β Geminorum No. 1373, of only moderately good quality, was selected as a test plate and has been measured fifteen times with different fundamental spectra, different arrangements of objectives and oculars and with two different ocular prisms.

The measures and their summary given below enable an estimate of the accuracy obtainable in measurement to be formed. Further ten additional plates of β Geminorum have been measured with constant conditions in the comparator, which enables an estimate to be formed of the instrumental errors to be expected in the making of the spectra. These also with a summary are given below:—

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♌ GEMINORUM 1373.

SOLAR STANDARD 1360.

Observer J. S. P.
Measurer J.

| Region. | d_1 | d_2 | d | F | i |
|---------|-------|-------|------------|--------|-------|
| 7 | 653 | 649 | 652 | 24.84 | -0.06 |
| 8 | 47 | 48 | 48 | 22.18 | -2.60 |
| 9 | 53 | 54 | 53 | 24.01 | -0.77 |
| 10 | 55 | 51 | 53 | 23.53 | -1.25 |
| 11 | 60 | 51 | 55 | 23.87 | -0.91 |
| 12 | 50 | 48 | 49 | 20.58 | -4.20 |
| 13 | 64 | 57 | 61 | 25.07 | -0.29 |
| 14 | 65 | 65 | 65 | 26.32 | -1.54 |
| 15 | 64 | 60 | 62 | 24.68 | +0.10 |
| 16 | 64 | 62 | 63 | 24.57 | -0.21 |
| 17 | 67 | 66 | 66 | 25.34 | -0.56 |
| 18 | 72 | 73 | 73 | 27.45 | -2.67 |
| 19 | 78 | 69 | 73 | 27.01 | -2.23 |
| 20 | 79 | 74 | 76 | 27.51 | -2.73 |
| 21 | 70 | 73 | 72 | 25.56 | -0.78 |
| 22 | 74 | 73 | 73 | 25.33 | -0.55 |
| 23 | 71 | 68 | 70 | 23.94 | +0.84 |
| 24 | 76 | 71 | 73 | 24.38 | +0.40 |
| 25 | 71 | 75 | 73 | 23.80 | +0.98 |
| 26 | 87 | 78 | 82 | 25.91 | -1.13 |
| 27 | 84 | 76 | 80 | 24.48 | +0.30 |
| 28 | 85 | 90 | 88 | 26.40 | +1.62 |
| 29 | 91 | 91 | 91 | 26.57 | +1.79 |
| 30 | 87 | 71 | 79 | 22.51 | +2.26 |
| 31 | 89 | 90 | 89 | 24.03 | -0.75 |
| | 1758 | 1688 | Mean . . . | +24.78 | |

$$\Sigma d = 3441$$

$$\log = .53668$$

$$\log f = .85865$$

$$\log (V_s - V_o) = 1.39533$$

$$r = \pm 1.10$$

$$V_s - V_o = -24.85$$

$$V_o = +0.21$$

$$V_a = -21.97$$

$$V_d = -0.16$$

$$V = +2.93$$

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3 GEMINORUM 1373.

SOLAR STANDARD 1461.

Observer J. S. P.
Measurer J.

| Region | d_1 | d_2 | d | V | ϵ |
|--------|-------|-------|-----------|--------|------------|
| 1 | 049 | 051 | 050 | 24.90 | -0.32 |
| 2 | 49 | 51 | 50 | 24.21 | +0.37 |
| 3 | 48 | 47 | 48 | 22.61 | -1.97 |
| 4 | 48 | 51 | 49 | 22.56 | -2.02 |
| 5 | 50 | 55 | 53 | 23.84 | +0.74 |
| 6 | 54 | 51 | 52 | 22.85 | +1.73 |
| 7 | 52 | 53 | 53 | 22.76 | -1.82 |
| 8 | 57 | 57 | 57 | 23.88 | +0.70 |
| 9 | 59 | 63 | 61 | 24.99 | -0.41 |
| 10 | 64 | 62 | 63 | 25.21 | -0.62 |
| 11 | 66 | 65 | 65 | 25.43 | -0.85 |
| 12 | 68 | 65 | 66 | 25.25 | -0.67 |
| 13 | 70 | 67 | 69 | 25.87 | -1.29 |
| 14 | 73 | 70 | 71 | 26.04 | -1.46 |
| 15 | 64 | 70 | 67 | 24.05 | +0.53 |
| 16 | 68 | 73 | 71 | 24.94 | -0.36 |
| 17 | 72 | 72 | 72 | 24.80 | -0.22 |
| 18 | 74 | 72 | 73 | 24.60 | -0.02 |
| 19 | 75 | 74 | 74 | 24.43 | +0.15 |
| 20 | 76 | 82 | 79 | 25.55 | -0.97 |
| 21 | 82 | 80 | 81 | 25.62 | -1.04 |
| 22 | 78 | 80 | 79 | 24.47 | +0.11 |
| 23 | 85 | 84 | 84 | 25.48 | -0.30 |
| 24 | 78 | 87 | 83 | 24.68 | -0.10 |
| 25 | 93 | 82 | 88 | 25.55 | -0.97 |
| | 1652 | 1638 | Mean..... | -24.58 | |

$$\Sigma d = 3310$$

$$\log = .51983$$

$$\log f = .87155$$

$$\log (V_s - V_o) = 1.39138$$

$$V_s - V_o = + 24.63$$

$$V_o = + 0.52$$

$$V_a = - 21.97$$

$$V_d = - 0.16$$

$$r = \pm 0.71$$

$$V = - 3.02$$

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 β GEMINORUM 1373.

SOLAR STANDARD 1461.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|---------|--------|-------|
| 3 | 055 | 051 | 053 | 24.96 | -1.06 |
| 4 | 45 | 52 | 48 | 22.10 | +1.80 |
| 5 | 47 | 53 | 50 | 22.49 | +1.41 |
| 6 | 50 | 47 | 49 | 21.53 | +2.37 |
| 7 | 53 | 53 | 53 | 22.76 | +1.14 |
| 8 | 49 | 51 | 50 | 20.95 | +2.95 |
| 9 | 58 | 63 | 60 | 24.58 | -0.68 |
| 10 | 64 | 62 | 63 | 25.21 | -1.31 |
| 11 | 66 | 59 | 60 | 23.47 | +0.43 |
| 12 | 65 | 61 | 63 | 24.10 | -0.20 |
| 13 | 67 | 62 | 64 | 24.00 | -0.10 |
| 14 | 68 | 72 | 70 | 25.68 | -1.78 |
| 15 | 69 | 62 | 66 | 23.69 | +0.21 |
| 16 | 79 | 65 | 72 | 25.29 | -1.39 |
| 17 | 68 | 69 | 69 | 23.78 | +0.12 |
| 18 | 68 | 76 | 72 | 24.26 | -0.36 |
| 19 | 74 | 74 | 74 | 24.43 | -0.53 |
| 20 | 74 | 72 | 73 | 23.61 | +0.29 |
| 21 | 77 | 74 | 75 | 23.72 | +0.18 |
| 22 | 78 | 79 | 78 | 24.16 | -0.26 |
| 23 | 79 | 81 | 80 | 24.26 | -0.36 |
| 24 | 88 | 83 | 86 | 25.57 | -1.67 |
| 25 | 91 | 82 | 86 | 24.97 | -0.07 |
| | 1526 | 1503 | Mean... | +23.90 | |

$$\Sigma d = 3029$$

$$\log = .48130$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.38001$$

$$c = \pm 0.81$$

$$V_s - V_o = + 23.99$$

$$V_o = + 0.35$$

$$V_s = - 21.97$$

$$Vd = - 0.16$$

$$V = + 2.23$$

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 β GEMINORUM 1373

SOLAR STANDARD 1462.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|-------|------------|-------|
| 4 | 049 | 049 | 049 | 22.56 | -2.12 |
| 5 | 52 | 51 | 51 | 22.94 | -1.44 |
| 6 | 53 | 54 | 54 | 23.73 | +0.65 |
| 7 | 60 | 57 | 58 | 24.91 | 0.53 |
| 8 | 53 | 52 | 53 | 22.21 | +2.16 |
| 9 | 64 | 57 | 60 | 24.58 | -0.20 |
| 10 | 65 | 61 | 63 | 25.21 | -0.83 |
| 11 | 67 | 64 | 66 | 25.82 | -1.44 |
| 12 | 63 | 67 | 65 | 24.87 | -0.49 |
| 13 | 68 | 69 | 68 | 25.50 | -1.12 |
| 14 | 73 | 70 | 72 | 26.41 | -2.03 |
| 15 | 67 | 64 | 65 | 23.34 | -1.04 |
| 16 | 67 | 67 | 67 | 23.54 | +0.84 |
| 17 | 68 | 73 | 71 | 24.47 | -0.09 |
| 18 | 73 | 71 | 72 | 24.26 | -0.12 |
| 19 | 69 | 70 | 69 | 22.78 | -1.60 |
| 20 | 76 | 74 | 75 | 24.26 | -0.12 |
| 21 | 83 | 83 | 83 | 26.25 | -1.87 |
| 22 | 78 | 84 | 81 | 25.09 | -0.71 |
| 23 | 79 | 79 | 79 | 23.96 | -0.42 |
| 24 | 81 | 82 | 81 | 24.08 | -0.30 |
| 25 | 89 | 87 | 88 | 25.59 | -1.21 |
| | 1497 | 1485 | Mean. | ... -24.38 | ... |

 $\Sigma d = 2992$ $\log = .47451$ $\log f = .91356$ $\text{Log } (V_s - V_o) = 1.38897$ $V_L - V_o = -24.44$ $V_o = -0.54$ $V_a = -21.97$ $V_d = -0.16$ $V = -2.85$ $r = -0.81$

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 β GEMINORUM 1373.

SOLAR STANDARD 1462.

Observer J. S. P.
Measurer

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|------|-------|-------|
| 1 | 052 | 051 | 051 | 25.40 | -0.72 |
| 2 | 48 | 49 | 49 | 23.72 | +0.96 |
| 3 | 55 | 50 | 52 | 24.50 | +0.18 |
| 4 | 47 | 47 | 47 | 21.64 | +3.04 |
| 5 | 50 | 54 | 52 | 23.39 | +1.29 |
| 6 | 52 | 51 | 52 | 22.85 | +1.82 |
| 7 | 60 | 54 | 57 | 24.48 | +0.20 |
| 8 | 58 | 57 | 57 | 23.88 | +0.80 |
| 9 | 61 | 62 | 62 | 25.40 | -0.72 |
| 10 | 65 | 62 | 63 | 25.21 | -0.53 |
| 11 | 64 | 61 | 63 | 24.65 | +0.03 |
| 12 | 73 | 70 | 71 | 27.16 | -2.48 |
| 13 | 74 | 66 | 70 | 26.25 | -1.57 |
| 14 | 67 | 69 | 68 | 24.94 | -0.26 |
| 15 | 65 | 67 | 66 | 23.69 | +0.99 |
| 16 | 72 | 67 | 70 | 24.58 | +0.10 |
| 17 | 70 | 69 | 69 | 23.77 | +0.93 |
| 18 | 72 | 72 | 72 | 24.26 | +0.42 |
| 19 | 74 | 74 | 74 | 24.45 | +0.25 |
| 20 | 78 | 76 | 77 | 24.90 | -0.22 |
| 21 | 84 | 79 | 81 | 25.62 | -0.94 |
| 22 | 82 | 82 | 82 | 25.40 | -0.72 |
| 23 | 85 | 79 | 81 | 24.57 | +0.11 |
| 24 | 82 | 81 | 82 | 24.38 | +0.30 |
| 25 | 94 | 87 | 90 | 26.13 | -1.45 |
| | 1682 | 1636 | Mean | 24.68 | |

$$\Sigma d = 3318$$

$$\log = .52988$$

$$\log f = .87155$$

$$\log (Vs - Vo) = 1.39243$$

$$Vs - Vo = + 24.68$$

$$Vo = + 0.48$$

$$Va = - 21.97$$

$$Vd = - 0.16$$

$$V = 3.03$$

$$r = \pm 0.77$$

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 β GEMINORUM 1373.

SOLAR STANDARD 1462.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|-------|--------|-------|
| 3 | 653 | 649 | 651 | 24.03 | +0.73 |
| 4 | 46 | 51 | 49 | 22.56 | +2.20 |
| 5 | 55 | 52 | 53 | 23.84 | +0.92 |
| 6 | 56 | 54 | 55 | 24.17 | +0.59 |
| 7 | 47 | 55 | 51 | 21.90 | +2.86 |
| 8 | 54 | 60 | 57 | 23.88 | +0.88 |
| 9 | 62 | 61 | 61 | 24.99 | -0.23 |
| 10 | 58 | 67 | 63 | 25.21 | -0.45 |
| 11 | 59 | 68 | 63 | 24.65 | +0.11 |
| 12 | 69 | 68 | 69 | 26.40 | -1.64 |
| 13 | 72 | 67 | 69 | 25.87 | -1.11 |
| 14 | 68 | 65 | 67 | 24.58 | +0.18 |
| 15 | 70 | 64 | 67 | 24.05 | +0.71 |
| 16 | 72 | 71 | 72 | 25.29 | -0.53 |
| 17 | 72 | 74 | 73 | 25.15 | -0.39 |
| 18 | 72 | 71 | 72 | 24.26 | +0.50 |
| 19 | 78 | 77 | 77 | 25.42 | -0.66 |
| 20 | 80 | 82 | 81 | 26.19 | -1.43 |
| 21 | 85 | 80 | 82 | 25.94 | -1.18 |
| 22 | 83 | 81 | 82 | 25.40 | -0.64 |
| 23 | 88 | 85 | 86 | 26.08 | -1.32 |
| 24 | 89 | 91 | 90 | 26.76 | -2.00 |
| 25 | 89 | 84 | 85 | 25.26 | -0.50 |
| | 1577 | 1577 | Mean. | -24.76 | .. |

$$\Sigma d = 3154$$

$$\log = .49886$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.39757$$

$$V_s - V_o = + 24.98$$

$$V_o = + 0.33$$

$$V_a = - 21.97$$

$$V_d = - 0.16$$

$$V = - 3.18$$

$$v = \pm 0.79$$

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 β GEMINORUM 1373.

SOLAR STANDARD 1462.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|------------|--------|-------|
| 1 | 049 | 047 | 048 | 23.91 | +0.27 |
| 2 | 44 | 51 | 48 | 23.24 | +0.94 |
| 3 | 50 | 51 | 50 | 23.55 | +0.63 |
| 4 | 50 | 45 | 48 | 22.19 | +2.08 |
| 5 | 53 | 51 | 52 | 23.39 | + .79 |
| 6 | 54 | 56 | 55 | 24.17 | + .01 |
| 7 | 60 | 59 | 60 | 25.76 | -1.58 |
| 8 | 56 | 58 | 57 | 23.88 | + .30 |
| 9 | 57 | 59 | 58 | 23.76 | + .42 |
| 10 | 59 | 60 | 60 | 24.01 | + .17 |
| 11 | 59 | 64 | 61 | 23.86 | + .32 |
| 12 | 60 | 66 | 63 | 24.10 | + .08 |
| 13 | 65 | 65 | 65 | 24.37 | - .19 |
| 14 | 66 | 68 | 67 | 24.58 | - .40 |
| 15 | 68 | 68 | 68 | 24.41 | - .23 |
| 16 | 60 | 64 | 62 | 21.77 | +2.41 |
| 17 | 70 | 75 | 72 | 24.80 | - .62 |
| 18 | 70 | 77 | 74 | 24.94 | - .76 |
| 19 | 74 | 72 | 73 | 24.10 | + .08 |
| 20 | 76 | 75 | 76 | 24.58 | - .40 |
| 21 | 82 | 74 | 78 | 24.67 | - .49 |
| 22 | 85 | 78 | 81 | 25.09 | - .91 |
| 23 | 85 | 78 | 82 | 24.87 | - .69 |
| 24 | 88 | 82 | 85 | 25.27 | -1.09 |
| 25 | 89 | 90 | 89 | 25.84 | -1.66 |
| 26 | 78 | 95 | 87 | 24.84 | - .66 |
| | 1707 | 1728 | Mean. | +24.18 | |

$$\Sigma d = 3435$$

$$\log = .53618$$

$$\log f = .84949$$

$$\log (Vs-Vo) = 1.38567$$

$$Vs-Vo = + 24.30$$

$$Vo = + 0.33$$

$$Va = - 21.97$$

$$Vd = - 0.16$$

$$r = \pm 0.63$$

$$V = + 2.50$$

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3 GEMINORUM 1373.

SOLAR STANDARD 1462.

High Power Objective.
Low Power Ocular.Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|-------|--------|-------|
| 3 | 953 | 959 | 951 | 24.63 | +0.28 |
| 4 | 59 | 47 | 49 | 22.56 | +1.73 |
| 5 | 53 | 50 | 51 | 22.94 | +1.37 |
| 6 | 60 | 51 | 56 | 24.61 | -0.39 |
| 7 | 57 | 53 | 55 | 23.62 | +0.69 |
| 8 | 58 | 53 | 55 | 23.04 | -1.27 |
| 9 | 59 | 57 | 58 | 23.76 | -0.55 |
| 10 | 59 | 62 | 61 | 24.41 | 0.10 |
| 11 | 63 | 65 | 64 | 25.01 | -0.73 |
| 12 | 66 | 73 | 69 | 26.40 | -2.09 |
| 13 | 73 | 69 | 71 | 26.62 | -2.31 |
| 14 | 73 | 64 | 69 | 25.31 | -1.00 |
| 15 | 69 | 65 | 67 | 24.65 | +0.26 |
| 16 | 71 | 66 | 68 | 23.88 | +0.43 |
| 17 | 66 | 69 | 68 | 23.43 | +0.88 |
| 18 | 72 | 70 | 71 | 23.93 | +0.38 |
| 19 | 73 | 66 | 70 | 23.11 | +1.20 |
| 20 | 75 | 77 | 76 | 24.58 | -0.27 |
| 21 | 81 | 73 | 77 | 24.36 | +0.64 |
| 22 | 87 | 74 | 80 | 24.78 | 0.47 |
| 23 | 80 | 73 | 77 | 23.35 | -0.96 |
| 24 | 86 | 83 | 84 | 24.97 | -0.66 |
| 25 | 97 | 85 | 91 | 26.42 | -2.11 |
| | 1575 | 1495 | Mean. | +24.31 | |

$$\Sigma d = 3070$$

$$\begin{aligned} \log &= 48714 \\ \log f &= 89871 \\ \log (V_s - V_o) &= 1.38585 \end{aligned}$$

$$r = \pm 0.74$$

$$\begin{aligned} V_s - V_o &= +24.32 \\ V_o &= +0.33 \\ V_s &= 21.97 \\ V_d &= 0.16 \end{aligned}$$

$$V = -2.52$$

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 β GEMINORUM 1373.

SOLAR STANDARD 1465.

Observer, J. S. P.
Measurer, J.

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|---------|---------|-------|
| 3 | 051 | 055 | 053 | 24.96 | -0.90 |
| 4 | 48 | 50 | 49 | 22.56 | +1.50 |
| 5 | 47 | 45 | 46 | 20.69 | -3.37 |
| 6 | 48 | 51 | 49 | 21.53 | +2.53 |
| 7 | 51 | 57 | 54 | 23.19 | +0.87 |
| 8 | 51 | 48 | 50 | 20.95 | +3.11 |
| 9 | 61 | 64 | 62 | 25.40 | -1.34 |
| 10 | 63 | 57 | 60 | 24.01 | +0.05 |
| 11 | 66 | 65 | 66 | 25.82 | -1.76 |
| 12 | 68 | 67 | 67 | 25.63 | 1.57 |
| 13 | 67 | 63 | 65 | 24.37 | -0.31 |
| 14 | 71 | 63 | 67 | 24.58 | 0.52 |
| 15 | 72 | 65 | 69 | 24.77 | 0.71 |
| 16 | 65 | 66 | 65 | 22.83 | +1.23 |
| 17 | 72 | 68 | 70 | 24.12 | -0.06 |
| 18 | 69 | 70 | 70 | 23.59 | +0.47 |
| 19 | 72 | 70 | 71 | 23.43 | +0.63 |
| 20 | 75 | 75 | 75 | 24.25 | 0.19 |
| 21 | 82 | 76 | 79 | 24.99 | -0.93 |
| 22 | 83 | 82 | 82 | 25.39 | -1.33 |
| 23 | 85 | 77 | 81 | 24.57 | -0.51 |
| 24 | 89 | 84 | 87 | 25.87 | -1.81 |
| 25 | 88 | 90 | 89 | 25.84 | -1.78 |
| | 1544 | 1508 | Mean... | + 24.06 | .... |

$$\Sigma d = 3052$$

$$\log = .48458$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.38329$$

$$V_s - V_o = + 24.17$$

$$V_o = + 0.27$$

$$V_o = - 21.97$$

$$V_d = 0.16$$

$$V = + 2.31$$

$$r = \pm 1.02$$

9-10 EDWARD VII., A. 1910

 β GEMINORUM 1373.SOLAR \dagger STANDARD 1468.Observer { J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|------------|--------|-------|
| 3 | 054 | 056 | 055 | 25.91 | -1.74 |
| 4 | 50 | 54 | 52 | 23.94 | +0.23 |
| 5 | 49 | 50 | 50 | 22.94 | +1.68 |
| 6 | 53 | 51 | 52 | 22.85 | +1.32 |
| 7 | 55 | 56 | 55 | 23.62 | +0.55 |
| 8 | 57 | 48 | 53 | 22.21 | +1.96 |
| 9 | 57 | 61 | 59 | 24.17 | 0.00 |
| 10 | 65 | 66 | 65 | 24.01 | -1.84 |
| 11 | 58 | 56 | 57 | 22.30 | +1.87 |
| 12 | 66 | 64 | 65 | 24.87 | -0.70 |
| 13 | 72 | 66 | 69 | 25.87 | -1.70 |
| 14 | 72 | 67 | 69 | 25.31 | -1.14 |
| 15 | 69 | 68 | 69 | 24.77 | -0.60 |
| 16 | 72 | 68 | 70 | 24.58 | 0.41 |
| 17 | 67 | 63 | 65 | 22.34 | +1.78 |
| 18 | 75 | 67 | 71 | 23.93 | +0.24 |
| 19 | 73 | 70 | 71 | 23.44 | +0.73 |
| 20 | 75 | 75 | 75 | 24.25 | -0.08 |
| 21 | 80 | 82 | 81 | 25.62 | -1.45 |
| 22 | 77 | 80 | 79 | 24.47 | -0.30 |
| 23 | 75 | 79 | 77 | 23.35 | +0.82 |
| 24 | 81 | 82 | 82 | 24.38 | -0.21 |
| 25 | 86 | 89 | 87 | 25.26 | -1.09 |
| | 1538 | 1518 | Mean. | +24.17 | .... |

$$\Sigma d = 3056$$

$$\log = .48515$$

$$\log f = .89871$$

$$\text{Log } (V_s - V_o) = 1.38386$$

$$V_s - V_o = + 24.20$$

$$V_o = + 0.23$$

$$V_a = - 21.97$$

$$V_d = - 0.16$$

$$V = + 2.30$$

$$r = \pm 0.80$$

SESSIONAL PAPER No. 25a

 β GEMINORUM 1373.

SOLAR STANDARD 1517.

High Power.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|---------|-------------|-------|
| 4 | 047 | 046 | 046 | 21.18 | +2.79 |
| 5 | 45 | 50 | 48 | 21.59 | +2.28 |
| 6 | 52 | 53 | 52 | 22.85 | +1.12 |
| 7 | 55 | 56 | 55 | 23.62 | +0.35 |
| 8 | 52 | 51 | 52 | 21.79 | +2.18 |
| 9 | 59 | 60 | 59 | 24.17 | -0.20 |
| 10 | 61 | 66 | 64 | 25.61 | -1.64 |
| 11 | 62 | 62 | 62 | 24.25 | -0.28 |
| 12 | 61 | 63 | 62 | 23.72 | +0.25 |
| 13 | 63 | 66 | 64 | 24.00 | -0.03 |
| 14 | 70 | 66 | 68 | 24.94 | -0.97 |
| 15 | 66 | 70 | 68 | 24.41 | -0.44 |
| 16 | 68 | 68 | 68 | 23.88 | +0.09 |
| 17 | 72 | 68 | 70 | 24.12 | -0.15 |
| 18 | 71 | 73 | 72 | 24.26 | -0.29 |
| 19 | 73 | 71 | 72 | 23.77 | +0.20 |
| 20 | 79 | 75 | 77 | 24.90 | -0.93 |
| 21 | 77 | 85 | 81 | 25.62 | -1.65 |
| 22 | 80 | 82 | 81 | 25.09 | -1.12 |
| 23 | 78 | 84 | 81 | 24.57 | -0.60 |
| 24 | 81 | 80 | 81 | 24.08 | -0.11 |
| 25 | 87 | 86 | 86 | 24.97 | -1.00 |
| | 1459 | 1481 | Mean... | +23.97 | ..... |

$$\Sigma d = 2940$$

$$\log = .46835$$

$$\log f = .91360$$

$$\log (V_s - V_o) = 1.38195$$

$$r = \pm 0.79$$

$$V_s - V_o = + 24.10$$

$$V_o = + 0.54$$

$$V_a = - 21.97$$

$$V_d = - 0.16$$

$$V = + 2.51$$

9-10 EDWARD VII., A. 1910

J GEMINORUM 1373.

SOLAR STANDARD 1519.

Observer J. S. P.
Measurer

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|-----------|--------|-------|
| 5 | 047 | 048 | 048 | 23.71 | +0.94 |
| 6 | 49 | 52 | 50 | 23.80 | +0.85 |
| 7 | 50 | 54 | 52 | 23.87 | +0.78 |
| 8 | 51 | 53 | 52 | 23.05 | -1.60 |
| 9 | 53 | 54 | 54 | 23.20 | -1.45 |
| 10 | 55 | 56 | 55 | 22.86 | +1.79 |
| 11 | 61 | 39 | 60 | 24.10 | +0.55 |
| 12 | 63 | 65 | 64 | 24.85 | +0.20 |
| 13 | 68 | 70 | 69 | 25.96 | -1.31 |
| 14 | 72 | 69 | 71 | 25.86 | -1.21 |
| 15 | 69 | 72 | 70 | 24.65 | 0.00 |
| 16 | 76 | 72 | 74 | 25.29 | -0.64 |
| 17 | 81 | 75 | 78 | 25.87 | -1.16 |
| 18 | 77 | 79 | 78 | 24.99 | -0.34 |
| 19 | 83 | 81 | 82 | 25.45 | -0.80 |
| 20 | 86 | 84 | 85 | 25.55 | -0.90 |
| 21 | 92 | 85 | 89 | 25.96 | -1.31 |
| | 1133 | 1128 | Mean..... | +24.65 | |

$$\Sigma d = 2261$$

$$\log = .35430$$

$$\log f = 1.03958$$

$$\log (V_s - V_o) = 1.39388$$

$$v = \pm 0.72$$

$$V_s - V_o = + 24.77$$

$$V_o = + 0.41$$

$$V_a = 21.97$$

$$V_d = - 0.16$$

$$V = +3.65$$

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3 GEMINORUM 1373.

SOLAR STANDARD 1520.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | δ |
|---------|-------|-------|-------|--------|----------|
| 5 | 046 | 048 | 047 | 23.22 | +1.70 |
| 6 | 53 | 51 | 52 | 24.75 | +0.17 |
| 7 | 50 | 51 | 51 | 23.41 | +1.61 |
| 8 | 59 | 57 | 58 | 25.71 | -0.79 |
| 9 | 57 | 60 | 58 | 24.92 | 0.00 |
| 10 | 59 | 55 | 57 | 23.69 | -1.23 |
| 11 | 64 | 64 | 64 | 25.71 | 0.79 |
| 12 | 68 | 68 | 68 | 26.41 | -1.48 |
| 13 | 72 | 70 | 71 | 26.71 | -1.79 |
| 14 | 67 | 72 | 70 | 25.49 | -0.57 |
| 15 | 68 | 72 | 70 | 24.65 | -0.27 |
| 16 | 73 | 69 | 71 | 24.27 | +0.65 |
| 17 | 73 | 73 | 73 | 24.17 | +0.75 |
| 18 | 73 | 81 | 80 | 25.63 | -0.71 |
| 19 | 83 | 81 | 82 | 25.45 | -0.53 |
| 20 | 79 | 83 | 81 | 24.35 | +0.57 |
| 21 | 88 | 84 | 86 | 25.09 | -0.17 |
| | 1147 | 1139 | Mean. | -24.92 | |

$$\Sigma d = 2286$$

$$\log = 35008$$

$$\log f = 1.03958$$

$$\log (V_s - V_o) = 1.39866$$

$$V_s - V_o = + 25.04$$

$$V_o = + 0.38$$

$$V_a = - 21.97$$

$$V_d = - 0.16$$

$$V = + 3.29$$

$$r = \pm 0.65$$

9-10 EDWARD VII., A. 1910

 β GEMINORUM 1373

SOLAR STANDARD 1524.

Observer. } J. S. P.
Measurer. }

| Region. | d_1 | d_2 | d | V | r |
|---------|-------|-------|-----------|--------|-------|
| 5 | 050 | 049 | 049 | 24.21 | +0.02 |
| 6 | 49 | 48 | 49 | 23.32 | +0.91 |
| 7 | 47 | 47 | 47 | 21.57 | +2.66 |
| 8 | 52 | 49 | 51 | 22.60 | +1.63 |
| 9 | 58 | 53 | 55 | 23.63 | +0.60 |
| 10 | 62 | 53 | 58 | 24.11 | +0.12 |
| 11 | 64 | 63 | 63 | 25.31 | -1.08 |
| 12 | 63 | 63 | 63 | 24.46 | -0.23 |
| 13 | 69 | 70 | 70 | 26.33 | -2.10 |
| 14 | 68 | 73 | 70 | 25.49 | -1.27 |
| 15 | 62 | 66 | 64 | 22.53 | +1.70 |
| 16 | 67 | 72 | 70 | 23.93 | +0.30 |
| 17 | 72 | 79 | 75 | 24.83 | +0.60 |
| 18 | 72 | 76 | 74 | 23.71 | -0.52 |
| 19 | 83 | 83 | 83 | 25.76 | -1.53 |
| 20 | 82 | 82 | 82 | 24.65 | -0.42 |
| 21 | 89 | 84 | 87 | 25.38 | -1.15 |
| | 1109 | 1110 | Mean. . . | +24.23 | ..... |

 $\Sigma d = 2219$ $\log = .34616$ $\log f = 1.03958$ $\log (V_s - V_o) = 1.38574$ $V_s - V_o = + 24.31$ $V_o = + 0.23$ $V_a = - 21.97$ $V_d = - 0.16$ $r = \pm 0.84$ $V = + 2.41$

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 β GEMINORUM 1306.Observer, } J. S. P.
Measurer, }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|------------|--------|-------|
| 3 | 023 | 020 | 021 | 9.89 | +0.47 |
| 4 | 22 | 22 | 22 | 10.13 | +0.23 |
| 5 | 19 | 18 | 19 | 8.55 | +1.83 |
| 6 | 24 | 21 | 23 | 10.11 | +0.25 |
| 7 | 28 | 25 | 26 | 11.16 | -0.80 |
| 8 | 25 | 23 | 24 | 10.06 | +0.30 |
| 9 | 26 | 28 | 27 | 11.06 | -0.70 |
| 10 | 22 | 24 | 23 | 9.20 | +1.16 |
| 11 | 32 | 26 | 29 | 11.34 | -0.98 |
| 12 | 28 | 24 | 26 | 9.95 | +0.41 |
| 13 | 30 | 21 | 26 | 9.75 | +0.61 |
| 14 | 26 | 30 | 28 | 10.27 | +0.09 |
| 15 | 30 | 38 | 34 | 12.21 | -1.85 |
| 16 | 26 | 26 | 26 | 9.13 | +1.23 |
| 17 | 29 | 36 | 32 | 11.02 | -0.66 |
| 18 | 27 | 25 | 26 | 8.76 | +1.60 |
| 19 | 36 | 24 | 30 | 9.90 | +0.46 |
| 20 | 38 | 31 | 35 | 11.32 | -0.96 |
| 21 | 37 | 28 | 32 | 10.12 | +0.24 |
| 22 | 36 | 32 | 34 | 10.53 | -0.17 |
| 23 | 41 | 35 | 38 | 11.53 | -1.17 |
| 24 | 40 | 37 | 39 | 11.59 | -1.23 |
| 25 | 38 | 36 | 37 | 10.74 | -0.38 |
| | 683 | 630 | Mean. | +10.36 | ..... |

$$\Sigma d = 1313$$

$$\log = .11826$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.01697$$

$$V_s - V_o = + 10.40$$

$$V_o = + 0.33$$

$$V_s = - 8.67$$

$$V_d = - 0.22$$

$$r = \pm 0.63$$

$$V = + 1.84$$

9-10 EDWARD VII., A. 1910

3 GEMINORUM 1417.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | ϵ |
|---------|-------|-------|------------|-------|------------|
| 3 | 061 | 058 | 059 | 27.79 | -0.80 |
| 4 | 65 | 65 | 65 | 29.93 | -1.34 |
| 5 | 59 | 58 | 59 | 26.54 | -2.05 |
| 6 | 66 | 64 | 65 | 28.56 | -0.03 |
| 7 | 67 | 65 | 66 | 28.34 | -0.25 |
| 8 | 65 | 64 | 65 | 27.24 | -1.35 |
| 9 | 74 | 69 | 71 | 29.08 | 0.49 |
| 10 | 73 | 77 | 75 | 30.01 | -1.42 |
| 11 | 75 | 76 | 76 | 29.73 | 1.14 |
| 12 | 77 | 76 | 76 | 29.08 | -0.49 |
| 13 | 78 | 75 | 77 | 28.87 | 0.28 |
| 14 | 82 | 74 | 78 | 28.61 | -0.02 |
| 15 | 78 | 79 | 78 | 28.00 | -0.59 |
| 16 | 80 | 76 | 78 | 27.39 | -1.20 |
| 17 | 79 | 77 | 78 | 26.87 | -1.72 |
| 18 | 83 | 84 | 84 | 28.31 | +0.28 |
| 19 | 85 | 85 | 85 | 28.06 | +0.53 |
| 20 | 91 | 87 | 89 | 28.78 | -0.19 |
| 21 | 96 | 96 | 96 | 30.36 | -1.77 |
| 22 | 96 | 96 | 96 | 29.73 | -1.14 |
| 23 | 92 | 94 | 93 | 28.21 | +0.38 |
| 24 | 94 | 100 | 97 | 28.84 | 0.25 |
| 25 | 105 | 98 | 101 | 29.32 | -0.73 |
| | 1821 | 1793 | Mean. | 28.59 | |

$$\Sigma d = 3615$$

$$\log = .55811$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.45682$$

$$\epsilon = \pm 0.68$$

$$V_s - V_o = + 28.63$$

$$V_o = - 0.33$$

$$V_s = - 27.36$$

$$Vd = - 0.19$$

$$V = - 1.41$$

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 β GEMINORUM 1424.Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|------|-------|-------|
| 3 | 063 | 060 | 062 | 29.21 | -0.07 |
| 4 | 61 | 61 | 61 | 28.68 | -1.06 |
| 5 | 62 | 63 | 62 | 27.89 | -1.25 |
| 6 | 66 | 63 | 65 | 28.36 | -0.58 |
| 7 | 65 | 66 | 65 | 27.91 | -1.23 |
| 8 | 62 | 60 | 61 | 25.56 | -3.58 |
| 9 | 68 | 71 | 69 | 28.26 | -1.88 |
| 10 | 72 | 74 | 73 | 29.21 | -0.07 |
| 11 | 74 | 70 | 72 | 28.17 | -0.97 |
| 12 | 70 | 82 | 76 | 29.08 | -0.06 |
| 13 | 73 | 82 | 78 | 29.25 | -0.11 |
| 14 | 78 | 83 | 80 | 29.34 | -0.20 |
| 15 | 77 | 83 | 80 | 28.72 | -0.42 |
| 16 | 83 | 85 | 84 | 29.50 | -0.36 |
| 17 | 89 | 91 | 90 | 31.00 | -1.86 |
| 18 | 94 | 93 | 93 | 31.34 | -2.20 |
| 19 | 87 | 93 | 90 | 29.70 | -0.56 |
| 20 | 92 | 96 | 94 | 30.40 | -1.26 |
| 21 | 90 | 94 | 92 | 29.10 | -0.04 |
| 22 | 97 | 98 | 98 | 30.35 | -1.21 |
| 23 | 90 | 96 | 93 | 28.21 | -0.93 |
| 24 | 101 | 107 | 104 | 30.92 | -1.78 |
| 25 | 106 | 103 | 105 | 30.48 | -1.34 |
| | 1820 | 1874 | Mean | 29.14 | |

$$\Sigma d = 3694$$

$$\log = .56750$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.46621$$

$$v = \pm 0.88$$

$$V_s - V_o = -29.26$$

$$V_o = +0.33$$

$$V_a = -27.89$$

$$V_d = -0.12$$

$$V = +1.58$$

9-10 EDWARD VII., A. 1910

 β GEMINORUM 1443.Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|---------|--------|-------|
| 3 | 061 | 060 | 061 | 28.76 | +2.80 |
| 4 | 66 | 67 | 66 | 30.39 | +1.17 |
| 5 | 66 | 65 | 66 | 29.69 | +1.87 |
| 6 | 66 | 67 | 66 | 29.00 | +2.56 |
| 7 | 68 | 75 | 72 | 30.92 | -0.64 |
| 8 | 74 | 78 | 76 | 31.84 | -0.28 |
| 9 | 80 | 77 | 78 | 31.95 | -0.39 |
| 10 | 78 | 80 | 79 | 31.62 | -0.06 |
| 11 | 79 | 83 | 81 | 31.69 | -0.13 |
| 12 | 86 | 87 | 87 | 33.29 | -1.73 |
| 13 | 87 | 82 | 84 | 31.50 | +0.06 |
| 14 | 86 | 86 | 86 | 32.64 | -1.08 |
| 15 | 85 | 88 | 87 | 31.23 | +0.33 |
| 16 | 92 | 83 | 88 | 30.91 | -0.65 |
| 17 | 93 | 94 | 93 | 32.05 | -0.49 |
| 18 | 95 | 95 | 95 | 32.01 | -0.45 |
| 19 | 92 | 94 | 93 | 30.70 | -0.86 |
| 20 | 100 | 99 | 100 | 32.34 | -0.78 |
| 21 | 104 | 96 | 100 | 31.63 | -0.07 |
| 22 | 107 | 103 | 105 | 32.52 | -0.96 |
| 23 | 108 | 106 | 107 | 32.45 | -0.89 |
| 24 | 114 | 108 | 111 | 33.00 | -1.44 |
| 25 | 118 | 114 | 116 | 33.67 | -2.11 |
| | 2005 | 1987 | Mean... | +31.56 | |

$$\Sigma d = 3992$$

$$\log = .60119$$

$$\log f = .89871$$

$$\log (V_s - V_o) = .49990$$

$$V_s - V_o = + 31.62$$

$$V_o = + 0.33$$

$$V_a = - 28.83$$

$$V_d = - 0.00$$

$$V = + 3.03$$

$$r = - 0.84$$

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 β GEMINORUM 1452.Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|-----------|--------|-------|
| 3 | 065 | 062 | 063 | 29 21 | +1 43 |
| 4 | 65 | 62 | 64 | 29 47 | +1 17 |
| 5 | 66 | 65 | 65 | 29 24 | +1 40 |
| 6 | 65 | 72 | 69 | 30 32 | +0 32 |
| 7 | 74 | 68 | 71 | 30 49 | +0 15 |
| 8 | 73 | 69 | 71 | 29 75 | +0 89 |
| 9 | 70 | 78 | 74 | 30 31 | +0 33 |
| 10 | 80 | 76 | 78 | 31 22 | -0 58 |
| 11 | 79 | 72 | 76 | 29 73 | +0 91 |
| 12 | 84 | 79 | 81 | 30 99 | -0 35 |
| 13 | 88 | 87 | 88 | 33 37 | -2 73 |
| 14 | 85 | 79 | 82 | 30 08 | +0 56 |
| 15 | 88 | 95 | 91 | 32 67 | -2 03 |
| 16 | 88 | 92 | 90 | 31 61 | -0 97 |
| 17 | 93 | 87 | 90 | 31 00 | -0 36 |
| 18 | 89 | 94 | 92 | 31 00 | -0 36 |
| 19 | 93 | 89 | 91 | 30 04 | +0 60 |
| 20 | 87 | 89 | 88 | 28 78 | +1 88 |
| 21 | 98 | 98 | 98 | 31 00 | -0 36 |
| 22 | 99 | 97 | 98 | 30 35 | +0 29 |
| 23 | 99 | 105 | 102 | 30 94 | -0 30 |
| 24 | 105 | 106 | 105 | 31 22 | -0 58 |
| 25 | 108 | 111 | 110 | 31 93 | -1 29 |
| | 1941 | 1932 | Mean..... | -30 64 | ..... |

$$\Sigma d = 3873$$

$$\log = .58805$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.48676$$

$$r = \pm 0.74$$

$$V_s - V_o = + 30.67$$

$$V_o = + 0.33$$

$$V_s = - 29.19$$

$$V_d = - 0.11$$

$$V = + 1.70$$

9-10 EDWARD VII., A. 1910

† GEMINORUM 1460.

Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|------------|-------|-------|
| 3 | 065 | 064 | 064 | 30.15 | -1.91 |
| 4 | 68 | 63 | 66 | 30.39 | +1.67 |
| 5 | 66 | 70 | 68 | 30.59 | +1.47 |
| 6 | 66 | 66 | 66 | 29.00 | +3.06 |
| 7 | 68 | 70 | 69 | 29.63 | 2.43 |
| 8 | 70 | 71 | 71 | 29.75 | +2.31 |
| 9 | 76 | 80 | 78 | 31.95 | -0.11 |
| 10 | 83 | 82 | 82 | 32.82 | -0.76 |
| 11 | 85 | 83 | 84 | 32.86 | -0.80 |
| 12 | 86 | 82 | 84 | 32.14 | -0.08 |
| 13 | 90 | 83 | 87 | 32.62 | -0.56 |
| 14 | 93 | 89 | 91 | 33.38 | -1.32 |
| 15 | 94 | 88 | 92 | 33.03 | 0.97 |
| 16 | 93 | 89 | 91 | 31.96 | +0.10 |
| 17 | 101 | 97 | 99 | 34.11 | -2.05 |
| 18 | 92 | 92 | 92 | 31.00 | +1.06 |
| 19 | 95 | 100 | 98 | 32.35 | -0.29 |
| 20 | 102 | 105 | 103 | 33.31 | -1.25 |
| 21 | 102 | 105 | 104 | 32.90 | -0.84 |
| 22 | 102 | 108 | 105 | 32.52 | -0.46 |
| 23 | 107 | 104 | 105 | 31.85 | +0.21 |
| 24 | 117 | 119 | 118 | 35.08 | -3.02 |
| 25 | 113 | 121 | 117 | 33.96 | -1.90 |
| | 2034 | 2031 | Mean. | 32.06 | |

$\Sigma d = 4065$

$\log = 60906$
 $\log f = 89871$
 $\log (V_z - V_o) = 50777$

$V_z - V_o = \pm 32.19$
 $V_o = \pm 0.33$
 $V_a = \pm 29.24$
 $Vd = \pm 0.09$

$V = \pm 3.19$

$c = \pm 1.14$

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4 GEMINORUM 1472.

SOLAR STANDARD 1520.

Observer J. S. P.
Measurer J.

| Region. | d_1 | d_2 | d | V | μ |
|---------|-------|-------|-------|--------|-------|
| 5 | 653 | 656 | 655 | 27.17 | +3.94 |
| 6 | 61 | 63 | 62 | 29.51 | +1.60 |
| 7 | 71 | 69 | 70 | 32.14 | -1.03 |
| 8 | 67 | 67 | 67 | 29.69 | +1.42 |
| 9 | 70 | 73 | 71 | 30.51 | +0.60 |
| 10 | 73 | 73 | 73 | 30.35 | +0.76 |
| 11 | 76 | 77 | 77 | 30.93 | -0.18 |
| 12 | 77 | 80 | 78 | 30.29 | +0.82 |
| 13 | 83 | 86 | 85 | 31.98 | +0.87 |
| 14 | 89 | 87 | 88 | 32.41 | -1.39 |
| 15 | 88 | 92 | 90 | 31.69 | -0.58 |
| 16 | 95 | 93 | 94 | 32.13 | -1.02 |
| 17 | 96 | 97 | 96 | 31.81 | +0.70 |
| 18 | 100 | 103 | 102 | 32.68 | -1.57 |
| 19 | 104 | 102 | 103 | 31.97 | +0.86 |
| 20 | 104 | 103 | 104 | 31.26 | -0.15 |
| 21 | 115 | 108 | 111 | 32.38 | +1.27 |
| | 1422 | 1429 | Mean. | +31.11 | ... |

$$\Sigma d = 2851$$

$$\log = 45500$$

$$\log f = 1.03958$$

$$\log (V_s - V_o) = 1.49458$$

$$V_s - V_o = -31.23$$

$$V_o = +0.38$$

$$V_a = -29.41$$

$$V_d = -0.21$$

$$V = 1.99$$

$$r = \pm 0.94$$

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 β GEMINORUM 1500.

SOLAR STANDARD 1519.

Observer } J. S. P.
Measurer }

| Region. | β_1 | d_2 | d | V | v |
|---------|-----------|-------|---------|-------|-------|
| 5 | 061 | 064 | 062 | 30.63 | +0.20 |
| 6 | 66 | 66 | 66 | 31.42 | -0.59 |
| 7 | 64 | 64 | 64 | 29.38 | +1.45 |
| 8 | 61 | 66 | 64 | 28.36 | +2.47 |
| 9 | 73 | 69 | 71 | 30.51 | +0.32 |
| 10 | 69 | 70 | 70 | 29.10 | +1.73 |
| 11 | 77 | 78 | 77 | 30.93 | -0.10 |
| 12 | 79 | 77 | 78 | 30.29 | +0.54 |
| 13 | 86 | 78 | 82 | 30.85 | -0.02 |
| 14 | 91 | 89 | 90 | 32.77 | -1.94 |
| 15 | 87 | 80 | 84 | 29.58 | +1.25 |
| 16 | 92 | 88 | 90 | 30.76 | +0.07 |
| 17 | 100 | 92 | 96 | 31.79 | -0.96 |
| 18 | 98 | 102 | 100 | 32.04 | -1.21 |
| 19 | 104 | 106 | 105 | 32.39 | -1.76 |
| 20 | 106 | 103 | 105 | 31.56 | -0.73 |
| 21 | 112 | 104 | 108 | 31.50 | -0.67 |
| | 1426 | 1396 | Mean... | 30.83 | ..... |

$$\Sigma d = 2822$$

$$\log = .45056$$

$$\log f = 1.03958$$

$$\log (Vs - Vo) = 1.49014$$

$$r = \pm 0.81$$

$$Vs - Vo = + 30.91$$

$$Vo = + 0.41$$

$$Va = - 29.14$$

$$Vd = - 0.15$$

$$V = + 2.03$$

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 β GEMINORUM 1502Observer } J. S. P.
Measurer }

| Region. | d_1 | d_2 | d | V | v |
|---------|-------|-------|-----------------|--------|-------|
| 3 | 659 | 665 | 662 | 29.21 | +1.98 |
| 4 | 69 | 62 | 65 | 29.93 | +1.26 |
| 5 | 65 | 65 | 65 | 29.24 | +1.95 |
| 6 | 64 | 70 | 67 | 29.44 | +1.75 |
| 7 | 67 | 68 | 68 | 29.20 | +1.99 |
| 8 | 73 | 71 | 72 | 30.17 | +1.02 |
| 9 | 82 | 76 | 79 | 32.36 | -1.17 |
| 10 | 83 | 81 | 82 | 32.82 | -1.63 |
| 11 | 79 | 80 | 80 | 31.30 | -0.13 |
| 12 | 85 | 90 | 87 | 33.29 | 2.10 |
| 13 | 89 | 87 | 88 | 33.00 | -1.81 |
| 14 | 80 | 86 | 83 | 30.44 | +0.75 |
| 15 | 88 | 88 | 88 | 31.59 | -0.40 |
| 16 | 90 | 85 | 88 | 30.91 | +0.28 |
| 17 | 89 | 91 | 90 | 31.02 | +0.17 |
| 18 | 89 | 91 | 90 | 30.33 | +0.86 |
| 19 | 99 | 100 | 99 | 32.68 | -1.49 |
| 20 | 100 | 100 | 100 | 32.34 | -1.15 |
| 21 | 98 | 100 | 99 | 31.31 | -0.12 |
| 22 | 108 | 102 | 105 | 32.32 | -1.13 |
| 23 | 101 | 93 | 97 | 29.42 | +1.77 |
| 24 | 108 | 114 | 111 | 33.00 | -1.81 |
| 25 | 110 | 113 | 111 | 32.22 | -1.63 |
| | 1975 | 1978 | Mean, | +31.19 | |

$$\Sigma d = 3953$$

$$\log = .59693$$

$$\log f = .89871$$

$$\log (V_s - V_o) = 1.49564$$

$$V_s - V_o = + 31.31$$

$$V_o = + 0.33$$

$$V_a = - 29.09$$

$$V_d = - 0.12$$

$$r = \pm 0.93$$

$$V = + 2.43$$

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 β GEMINORUM 1527.

SOLAR STANDARD 1529.

Observer J. S. P.
Measurer

| Regions. | d_1 | d_2 | d | Γ | v |
|----------|-------|-------|-------------------|----------|-------|
| 5 | 047 | 053 | 050 | 24 70 | +2 16 |
| 6 | 51 | 52 | 52 | 24 75 | +2 11 |
| 7 | 55 | 58 | 56 | 25 71 | +1 15 |
| 8 | 62 | 61 | 62 | 27 48 | -0 62 |
| 9 | 58 | 64 | 61 | 26 21 | -0 65 |
| 10 | 60 | 64 | 62 | 25 77 | -1 09 |
| 11 | 69 | 65 | 67 | 26 91 | -0 05 |
| 12 | 66 | 72 | 69 | 26 79 | -0 07 |
| 13 | 74 | 73 | 73 | 27 46 | -0 60 |
| 14 | 75 | 79 | 77 | 28 04 | 1 18 |
| 15 | 83 | 74 | 79 | 27 82 | -0 96 |
| 16 | 85 | 82 | 83 | 28 37 | -1 51 |
| 17 | 86 | 82 | 84 | 27 81 | -0 95 |
| 18 | 87 | 79 | 83 | 26 59 | -0 27 |
| 19 | 93 | 90 | 91 | 28 25 | 1 39 |
| 20 | 90 | 90 | 90 | 27 05 | 0 19 |
| 1141 | | 1138 | Mean +26 86 |  | ..... |

 $\Sigma d = 2279$ $\log = .35774$ $\log f = 1.07349$ $\log (V_s - V_o) = 1.43123$ $V_s - V_o = -26.99$ $V_o = -0.38$ $V_a = 24.85$ $V_d = -0.24$ $r = \pm 0.77$ $V = -2.37$ SUMMARY OF COMPARATOR MEASURES OF β GEMINORUM 1373.

| Solar Standard. | No. of Regions. | Velocity. | Residual O - C. | Probable error of Single Region. |
|-----------------|-----------------|-----------|-----------------|----------------------------------|
| 1360 | 25 | +2 93 | -0 21 | ± 1.10 |
| 1461 | 25 | +3 02 | -0 31 | 0 71 |
| 1461 | 23 | +2 23 | +0 49 | 0 81 |
| 1462 | 22 | +2 85 | -0 13 | 0 81 |
| 1462 | 25 | +3 03 | -0 31 | 0 77 |
| 1462 | 23 | +3 18 | -0 46 | 0 79 |
| 1462 | 26 | +2 50 | +0 22 | 0 63 |
| 1462 | 23 | +2 52 | +0 20 | 0 74 |
| 1465 | 23 | +2 31 | +0 41 | 1 02 |
| 1468 | 23 | +2 30 | -0 42 | 0 80 |
| 1517 | 22 | +2 51 | -0 21 | 0 79 |
| 1519 | 17 | +3 05 | -0 33 | 0 72 |
| 1520 | 17 | +3 29 | -0 57 | 0 65 |
| 1524 | 17 | +2 41 | +0 31 | 0 84 |

Mean velocity + 2 72.

Mean P. E. ± 0.80 .Probable error of single measure = ± 0.24 km.Probable error of mean velocity = ± 0.065 km.

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SUMMARY OF MEASURES OF 11 PLATES OF β GEMINORUM.

| Plate No. | No. of Regions. | Velocity. | Residual. | Probable error of Single Region. |
|-----------|-----------------|-----------|-----------|--|
| 1306. | 23 | +1.84 | +0.37 | +0.63 |
| 1373. | 23 | 2.72 | -0.51 | 0.80 |
| 1417. | 23 | 1.41 | +0.80 | 0.68 |
| 1424. | 23 | 1.58 | +0.63 | 0.88 |
| 1443. | 23 | 3.03 | -0.82 | 0.84 |
| 1452. | 23 | 1.70 | +0.51 | 0.74 |
| 1460. | 23 | 3.19 | -0.98 | 1.14 |
| 1472. | 17 | 1.99 | +0.22 | 0.94 |
| 1500. | 17 | 2.03 | +0.18 | 0.81 |
| 1502. | 23 | 2.43 | -0.22 | 0.93 |
| 1527. | 16 | 2.37 | -0.16 | 0.77 |

Mean velocity + 2.21.

Mean P. E. \pm 0.83.Probable error of plate = \pm 0.40.Probable error of mean = \pm 0.12.

As the summaries and probable errors above show, the error of setting on a single region is on the average in the several measures of the plate No. 1373 \pm 0.80km., and only slightly greater \pm 0.83 for the other plates. Hartmann obtained a probable error of \pm 0.67km., somewhat smaller than above. The difference may be due partly to his greater skill and experience in measurement and partly possibly to better quality of spectra. If a better spectrum than 1373 had been selected and it were measured with the best of the fundamental spectra, I have no doubt the probable error would be considerably diminished.

The measures of the 11 plates of β Geminorum give an indication of the systematic discrepancies to be expected in the production of the spectra, although some allowance should be made for accidental errors of measurement. A total range of nearly 1.8km. is shown and the probable error of a plate is \pm 0.40km. These plates were made under average conditions, no special care being taken, and the plates are of average quality only. A systematic difference between these measures and other determinations by the old method of measurement at this, and other observatories of slightly over a kilometre + 3.5km. with micrometer microscope, + 2.2km. with comparator is present. These plates have only been measured by the comparator, and hence it cannot be determined yet whether this difference is in the plates or in the method of measurement, but the latter seems the more probable. It is interesting to note in this connection that there is a gradual and systematic increase in the velocity of the different regions from the red to the violet in all the star plates measured, but no explanation of the cause of this discrepancy can be offered. It is unquestionable that if this were removed the probable error of a single region would be materially reduced. Finally, it is probable that, as more experience is gained with the instrument, the accuracy of the measures will be considerably increased.

THE COELOSTAT TELESCOPE.

Although the optical and mechanical parts of this instrument have been ready for nearly two years, the shelter and connecting passage and tunnel were not finally completed until about July, 1908, and it was not possible to make any use of the installation until some time after that date. The spectrograph, which is described by Dr. DeLury in Appendix C, was erected and adjusted as soon after as possible, but owing to the inferior quality of the grating, the work has been much handicapped.

The telescope itself performs admirably and as it has not yet been described, it seems desirable to mention here its principal features.

Essentially the optical parts of the installation consist of the coelostat mirror, which reflects the sun's light in a southerly direction to a secondary plane mirror, which in turn reflects the beam north to a concave mirror forming a solar image 80 feet south in the basement of the observatory building.

A general view of the coelostat and secondary mirror, and of the shelters and connecting passages for the beam is given in Fig. 13. The coelostat and secondary mirror are covered by a house on wheels, which can be easily rolled back (and is thus shown in the figure) by a convenient mechanism over the louvred passageway which contains the concave mirror. Between the latter and the basement of the Observatory is another ventilated passage and a tunnel. The house and passages are constructed of wood, covered with galvanized iron painted white, and all very thoroughly ventilated by galvanized iron louvres to prevent as far as possible temperature stratification or disturbance in the course of the beam. It would have been preferable to continue the ventilated passage along the whole course of the beam from the coelostat to the Observatory wall, but this was not possible on account of the necessity of a driveway. This difficulty was overcome by making a tunnel for the last 20 feet, or so, through which the beam passes to the focus. As the latter is usually five feet or so outside the wall, this leaves an unventilated distance of about 15 feet, which apparently has no very serious effect on the definition.

A general view of the telescope looking north is given in Fig. 14, and another view looking south towards the Observatory in Fig. 15. The coelostat has a plane mirror 20 inches in diameter which rotates on an axis, in or parallel to its plane, which is parallel to the axis of the earth and driven by clockwork at half the diurnal rate. The whole instrument is moved bodily east and west by the sheave and cable, shown in the figures, on cast-iron ways resting on a cement pier. The purpose of this movement is to enable the coelostat mirror to receive the sun light more nearly normally by placing it towards the west in the morning and the east in the afternoon. The ways are long enough to permit of sufficient movement to prevent any interception of the return beam from the concave, which passes under the secondary mirror.

The beam of sunlight from the coelostat mirror is reflected in a constant direction so long as the declination remains the same, but evidently any change in the declination of the incident light entails a similar change in the direction of the reflected light, and it is necessary to have a movable secondary mirror to receive this beam and direct it towards the image forming concave. This change of direction of the reflected beam, due to the change of declination of the sun, is provided for by attaching the mirror to a carriage rolling on ways in a north and south direction, the mechanism for changing the position of the secondary being identical with that used for moving the coelostat and the concave mirror, and being well shown in the figures. During the winter when the sun is low in the sky, the secondary has to be brought close to the coelostat, and in the summer away from it. The secondary mirror, also of 20 inches diameter, can be quickly adjusted in inclination by quick and slow motions so as to send the beam directly to the concave mirror.

The latter of 18 inches diameter and 80 feet focus is movable in the north and south direction over ways about 20 feet long, in order to be able to vary the position of the image for different purposes. It is also adjustable vertically and has slow motions provided for moving around a vertical and horizontal axis in order to place any desired part of the image, say, on the slit of the spectroscope or in any other required position. The beam of light from this mirror passes directly under the secondary mirror through the opening in its support, and is inclined downward $3\frac{1}{2}^{\circ}$, the same inclination being given to the ways on which the concave mirror carriage moves. This inclination was adopted in order to enable the coelostat to be raised a little above

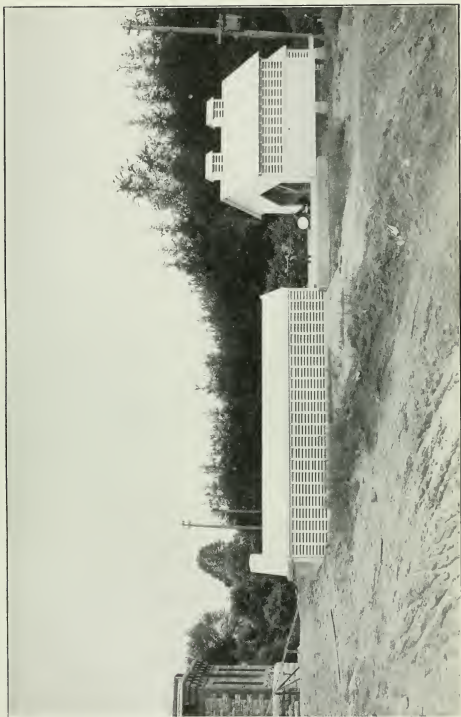


FIG. 13—Celostat House.

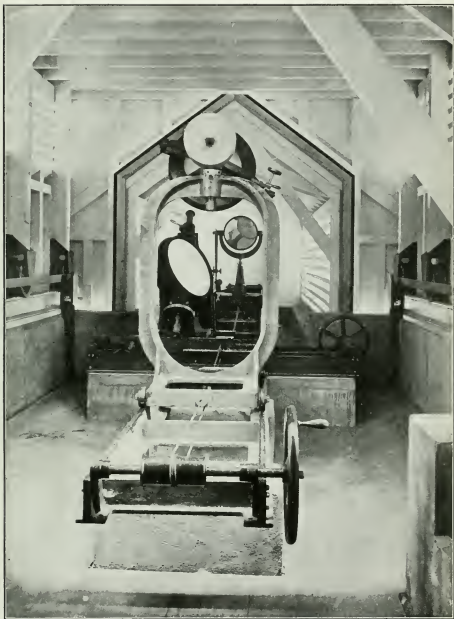


FIG. 14—Celostat Telescope Mechanism, looking north.



FIG. 15—Celostat Telescope Mechanism, looking south.

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the surface of the ground, and to keep the beam some distance away from the roof of the tunnel.

The coelostat was made by the J. A. Brashear Co., in 1905, for eclipse purposes, and the secondary and concave mirrors in 1907. The designs and drawings for the remainder of the mechanical parts were made by myself, while the mechanism was constructed by the Victoria Foundry. It was found necessary, owing to the vibration of the secondary mirror support and carriage by the wind, to design one of a heavier pattern, which has been constructed by the same firm since the photographs were made, and entirely overcomes the difficulty.

The definition given by this equipment is much better than was expected from the somewhat unfavourable conditions, such as the low position of the coelostat, and the presence of the unventilated tunnel through which the beam passes. Its location north of the Observatory is also objectionable on account of radiation or convection from the building, affecting the beam between coelostat and sun. However, as the position of the installation was the only one available, we were forced to make the best of these adverse conditions and as the result shows successfully. In the early morning and the late afternoon when the mirrors are in their normal condition the definition is very good, but this is soon deteriorated by the irregular figure produced by the heating action of the sun on the mirrors. However, by keeping them shielded from the sun's rays except during actual use, this causes no especial difficulty in solar rotation work.

RADIAL VELOCITIES.

The work of determining the radial velocities of stars has been actively carried on during the last year, the addition to the staff enabling a considerable increase in the number of measurements made, and in the amount of computational work accomplished. So far as observing is concerned, however, the weather has not been as good as in the previous year. In April and May there were considerably fewer observing nights, many of them also being rendered practically useless by haze. June, July and August were good, but they were followed by three months in which very few useful spectra were obtained owing to continuous dense smoke at first and afterwards to cloudy weather. The remainder of the year has been of about average quality. There have been photographed in the year, 1,010 spectra, 18 sun for use with the spectro-comparator and 992 star spectra on 160 nights. Of these 218 have been made with the three-prism, 698 with the one-prism and 94 with the new one-prism spectrograph.

Of these spectra, 775 have been measured and reduced. Probably a number of spectra made previous to April 1, 1908, have also been measured during the past year, but we have no record of the exact number.

Detailed measures, which in this report have all been collected together at the end (Appendix E), have been made of 635 plates, of which 581 are used in obtaining the orbits of the five binary stars discussed below. The other 54 are measures of two stars whose orbits are not yet completed. The remaining 138 plates measured are chiefly of spectroscopic binaries under investigation, but they also include a number of plates of some early type stars not known to be binaries.

The five binaries discussed below with the number of plates used for each are:—

| Star. | Right Ascension | | Declination. | No. of Plates. |
|----------------------------|-----------------|------|--------------|------------------|
| | h. | m. | | |
| β Orionis..... | 5 | 10 | - 8° 19' | 273 |
| θ Aquile..... | 20 | 06.2 | - 1 7 | 54, + 43 in 1908 |
| α Coronæ Borealis.. | 15 | 30.4 | + 27 3 | 103 |
| ϵ Herculis..... | 16 | 56.5 | + 31 4 | 106 |
| γ Boötis..... | 13 | 49.9 | + 18 54 | 45 |

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The 34 measures of δ Aquila which follow are given for the reason that there seems little prospect of obtaining an orbit and little use, owing to the uncertainty of the results and the small range in velocity, in carrying the work on this star any further.

The binaries under observation here at present are given in the following table. In two of these stars τ Tauri, B.D. - 1° 1004, and ν Orionis, the work is well advanced, but on many of the others not much has yet been done:—

BINARIES UNDER OBSERVATION.

| — | R. A. | Declination. | | Mag. | Type. |
|------------------------------|---------|--------------|----|------|---------|
| | h. m. | ° | ' | | |
| ϕ Persei..... | 1 37 | + 50 | 11 | 4.3 | I a 2 |
| τ Tauri..... | 4 36 | + 22 | 36 | 4.2 | I b |
| γ Camelopardalis..... | 4 49.3 | + 53 | 35 | 4.7 | VII a |
| B. D. - 1° 1004..... | 5 36 | - 1 | 11 | 5.1 | I b |
| ν Orionis..... | 6 1.8 | + 14 | 47 | 4.6 | IV a, b |
| γ Geminorum..... | 6 31.9 | + 16 | 9 | 2.9 | VIII a |
| ω Ursæ Majoris..... | 10 48.2 | + 43 | 43 | 4.7 | I a 2 |
| 93 Leonis..... | 11 43 | + 20 | 46 | 4.8 | XII |
| γ Corvi..... | 12 11 | - 16 | 59 | 3.3 | VI a |
| δ Herculis..... | 17 11 | + 24 | 57 | 3.7 | VII b |
| B.A.C. - 5890..... | 17 21.3 | - 5 | 0 | 4.8 | XII |
| α Ophiuchi..... | 17 30 | + 12 | 37 | 2.9 | XIII b |
| γ Aquarii..... | 22 16 | - 1 | 53 | 4.1 | VII a |

The majority of these stars have, as will be noticed, early type spectra and in many of them the lines are very diffuse; consequently many plates are required before a satisfactory orbit can be obtained, an example of this being given in the preceding table of the binaries completed, where the average number of plates used is well over 100.

In the measures of stars not known to be binaries, those that were observed having in every case spectra of the hydrogen or helium type generally with diffuse lines, the following four stars were discovered to be variable in their velocity:—

NEW SPECTROSCOPIC BINARIES.

| Star. | R. A. | Declination. | | Mag. | Type. |
|---------------------------|---------|--------------|----|------|-------|
| | h. m. | ° | ' | | |
| δ Herculis..... | 17 11 | + 24 | 57 | 3.7 | VII b |
| γ Aquarii..... | 22 16.5 | - 1 | 53 | 4.1 | VII a |
| ϵ Andromedæ..... | 23 33.2 | + 42 | 43 | 4.4 | A |
| ζ Persei..... | 3 52.4 | + 35 | 30 | 4.4 | I b |

In addition to the above, β Orionis is definitely announced as of binary character, but as it is more fully discussed later, nothing more need be said about it here.

 δ Herculis.

Practically the only lines measurable in this spectrum are the hydrogen series, and these are very diffuse and difficult to measure. Consequently, the measures are

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subject to much uncertainty, and it was only after several plates had been obtained that its binary character was established. The velocities are as follows:—

| Plate Number. | Date. | Velocity. | Plate Number. | Date. | Velocity. |
|---------------|------------|-----------|---------------|-------------|-----------|
| 1907. | | | 1908. | | |
| 839 | June 12 79 | - 27 | 1404 | March 16 93 | - 44 |
| 894 | " 27 74 | - 9 | 1480 | April 13 83 | - 73 |
| 929 | July 9 66 | - 35 | 1495 | " 15 89 | - 47 |
| 1908. | | | 1512 | " 22 89 | - 57 |
| 1392 | March 8 89 | - 59 | 1532 | May 15 85 | - 47 |
| | | | 1541 | " 18 81 | - 18 |

The variability in its velocity was discovered by Mr. Harper.

γ Aquarii.

This star is of the hydrogen type, having *Mg.* 4481, *Fe* 4549, *Ca* 3934, in addition to the hydrogen lines, and the measures are consequently much more reliable than the previous star. They are:

| Plate Number. | Date. | Velocity. | Plate Number. | Date. | Velocity. |
|---------------|-------------|-----------|---------------|--------------|-----------|
| 1908. | | | 1908. | | |
| 1745 | July 29 86 | - 18 | 1790 | August 17 81 | - 40 |
| 1770 | August 5 81 | - 8 | 1847 | " 28 70 | - 7 |
| 1779 | " 7 81 | + 3 | 1858 | " 31 77 | + 23 |

Its variability was discovered by Mr. Cannon.

ι Andromedæ.

The spectrum of this star is similar to that of *γ Aquarii*, having the hydrogen *Mg.* 4481, and *K* lines, although possibly not so well defined. Its variability was discovered by Mr. Cannon, and it was announced in the *Journal of the Royal Astronomical Society of Canada*, Vol. II., No. 5. I learned afterwards that it had been informally announced by Prof. Frost at the Put-in-Bay meeting of the Astronomical and Astrophysical Society of America. Although present at the meeting, I had taken no notes and had forgotten its announcement. The discovery here was consequently entirely independent. The velocities of all the plates measured here are given:

| Plate Number. | Date. | Velocity. | Plate Number. | Date. | Velocity. |
|---------------|--------------|-----------|---------------|---------------|-----------|
| 1908. | | | 1908. | | |
| 1772 | August 5 87 | - 6 | 1954 | November 9 58 | 0 |
| 1781 | " 7 87 | - 11 | 1963 | " 13 60 | + 14 |
| 1832 | " 26 87 | + 12 | 1969 | " 16 69 | + 29 |
| 1922 | October 9 76 | - 36 | 1971 | " 20 59 | - 13 |
| 1928 | " 12 71 | 14 | 1977 | " 21 53 | + 7 |
| 1939 | " 19 63 | 6 | 1995 | December 2 55 | + 1 |

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 ϵ Persei.

The spectrum of this star is of the helium type, and is principally characterized by the extreme breadth and diffuseness of the lines. Frost and Adams, in 1903, published the measures of some plates which agreed well within errors of observation in giving it a positive velocity of 85km. per second. They surmised that later plates might show the velocity to be variable. Consequently, I thought it desirable to obtain a few plates here, and their measures by Mr. Cannon soon showed that the star was a binary. I have since learned personally from Prof. Frost that this had been a long time established by them. The following are all the velocities measured here:—

| Plate Number. | Date, G. M. T. | Velocity. | Plate Number. | Date, G. M. T. | Velocity. |
|---------------|----------------|-----------|---------------|----------------|-----------|
| | 1908. | | | 1908. | |
| 1946 | October 30·37 | - 120 | 1974 | November 20·83 | - 45 |
| 1953 | November 6·66 | - 143 | 1998 | December 2·69 | - 32 |
| 1958 | " 9·77 | - 54 | 1999 | " 4 72 | - 51 |
| 1964 | " 13·65 | - 2 | | | |

 δ Aquilæ.

Mr. Parker has spent considerable time at work on δ Aquilæ without being able to obtain a period, and it looks as if the small range, combined with the poor quality of the spectrum, will prevent any orbit being determined. Mr. Parker has also been unfortunate in the other binary on which he has been engaged, τ Tauri, which has very bad lines in its spectrum and over which he has spent a great deal of time. He has, however, determined the period as nearly 1·5 days, but it has not been thought desirable to complete the work until further plates are secured next season. Consequently no measures of it will be given in this report, but a summary of the measures and some data concerning δ Aquilæ are given below, while the detailed measures are given in Appendix E.

This star ($\alpha = 19^h 20^m.5$, $\delta = 2^\circ 55'$) was discovered to be of variable velocity by Campbell and Curtis from observations made at the Lick Observatory in 1900-03.* Observations were begun upon it here in August, 1906, and since then some thirty-four plates have been measured and computed. δ Aquilæ is taken as the typical star in Group XL, according to Miss Maury's classification.† The principal lines in the spectrum are those of hydrogen, iron, magnesium and titanium. All, and especially those of hydrogen, are broad and not defined, the region measured being from $H\beta$ to λ 4005. These will be found in Table I. The range of resulting radial velocities, as seen in Table II. is not large (- 15 to - 47kms.), and, as yet the period cannot be determined from the curve of the present observations.

* L.O.B., 1903, A. J. XVIII., 306.

† Annals Harvard College Observatory, Vol. 28.

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TABLE I.
PRINCIPAL LINES MEASURED IN δ AQUILÆ.

| Wave-Length. | Element. | Wave-Length. | Element. |
|---------------|------------|---------------|----------|
| 4861.527..... | H | 4274.922..... | Ti & Cr |
| 4549.766..... | Fe & Ti | 4271.760..... | Fe |
| 4534.139..... | Ti | 4260.640..... | Fe |
| 4501.448..... | Ti | 4246.995..... | Y |
| 4481.400..... | Mg | 4227.010..... | Fe |
| 4443.976..... | Ti | 4216.351..... | Fe |
| 4404.927..... | Fe | 4198.494..... | Fe |
| 4395.286..... | Ti, V, Zy. | 4143.928..... | Fe |
| 4374.905..... | Ti | 4102.000..... | H |
| 4340.634..... | H | 4071.901..... | Fe |
| 4325.939..... | Fe | 4063.756..... | Fe |
| 4320.992..... | Sc | 4045.975..... | Fe |
| 4282.722..... | Fe | 4005.429..... | Fe |

TABLE II.
TABLE OF OBSERVATIONS OF δ AQUILÆ.

| Plate. | Date, G. M. T. | Velocity. |
|---------------|--------------------|------------|
| 368..... | 1906, August, 6 73 | -41.8 kms. |
| 377..... | " 15 65 | 45.2 |
| 382..... | " 24 65 | 45.1 |
| 390..... | Sept. 10 64 | 25.0 |
| 399..... | " 27 61 | 29.0 |
| 413..... | Oct. 23 57 | 37.7 |
| 803..... | 1907, May, 31 79 | 29.9 |
| 818..... | June, 10 80 | 42.8 |
| 904..... | July, 2 76 | 19.5 |
| 923..... | " 8 75 | 28.0 |
| 930..... | " 9 68 | 15.6 |
| 938..... | " 10 68 | 18.5 |
| 966..... | " 25 68 | 16.5 |
| 980..... | Aug. 3 61 | 25.7 |
| 982..... | " 5 68 | 29.4 |
| 1034..... | Sept. 6 65 | 25.4 |
| 1049 (a)..... | " 18 58 | 25.9 |
| 1049 (b)..... | " 18 58 | 28.0 |
| 1543..... | 1908, May, 18 83 | 21.9 |
| 1550..... | " 22 85 | 40.1 |
| 1575..... | June, 3 83 | 28.2 |
| 1575..... | " 3 83 | 31.6 |
| 1584..... | " 5 85 | 35.5 |
| 1633..... | " 24 77 | 29.5 |
| 1642..... | " 26 78 | 39.8 |
| 1650..... | " 27 75 | 40.9 |
| 1660..... | July, 3 77 | 21.9 |
| 1678..... | " 8 75 | 36.4 |
| 1690..... | " 10 77 | 26.1 |
| 1695..... | " 11 77 | 34.6 |
| 1703..... | " 13 78 | 47.0 |
| 1753..... | " 31 69 | 30.7 |
| 1754..... | " 31 72 | 39.1 |
| 1768..... | August, 5 75 | 29.7 |
| 1783..... | " 15 73 | 31.9 |
| 1837..... | " 27 62 | -39.5 |

THE ORBIT OF β ORIONIS.

As was mentioned in my report of last year, under a description and discussion of the effect of slit-width on the errors of setting, this star showed such a difference in the mean velocities obtained on two nights (mean of 10 plates on March 20, 24.9km.; mean of 12 plates on March 24, 20.6km.) as to lead to a strong suspicion of the variability of its velocity. This suspicion was strengthened by plates obtained on other nights up to April 13, 1908, and it was decided on account of its brightness and its interesting history to follow it closely as soon as it again came into position where it could be observed.

The radial velocity of β Orionis was first determined at Potsdam by Vogel and Scheiner* in the years 1888-1891, in the beginning of photographic determinations of radial velocity. From their measures of the 14 plates, velocities varying between about +3 and +34kms. per second were obtained. They suspected a variation in the star's velocity due to orbital motion, but were unable to obtain evidence of its periodicity, and the accuracy of these early measures was scarcely sufficiently high to decide the question. The next published measures of the star's velocity were by Frost and Adams† from plates obtained in 1901-1902. They found values ranging between +14.9 and +23.4km., but they attributed this range to the character of the lines in the star's spectrum and concluded that their results showed no indication of variability in velocity. The measures of 5 plates of β Orionis obtained at the Lick Observatory‡ indicate a range of 10km. from +15 to +25km., in its velocity, but Campbell and Curtis in discussing these measures attribute this range to the small number of lines available, to their poor quality, and to over-exposure of some of the negatives. They consider that proper exposure would considerably reduce the observed range, and conclude that their results do not give any evidence of variability of velocity. However, a recent personal communication from Prof. Campbell informs me that they have suspected variation, but owing to press of their regular programme have not followed up the matter.

There seemed to be no question of the smallness of the range in velocity, if any, and it was evident that the only hope of obtaining anything definite, considering this and the fairly large accidental errors of a velocity determination owing to the character of the lines of the spectrum, was to obtain several plates on each night the star was observed and use their mean velocity as the velocity of the star at their mean epoch. As the star is bright, a spectrum can be obtained in ten minutes or less with the three-prism spectrograph, and in about two minutes with the one-prism. Consequently not much time is required to obtain half a dozen plates and unless the period is very short no error due to change of phase can enter. The probable error of a night's observation will by this means be considerably reduced and a much better chance obtained of determining its period of variation.

Plates were accordingly obtained whenever possible until the star became inaccessible in April, 1908, and observations were continued during the present season until March 23, 1909. Owing to the very smoky and cloudy weather last fall, very few plates were obtained until December. In all 273 plates, obtained on 54 nights, have been used in this discussion. Of these 150 were made with a dispersion of three prisms, 123 with one prism. The investigation on slit-width in the last report showed that lower probable errors were obtained with the higher dispersion and it was used wherever possible. However, the star was also observed with the one-prism spectrograph when our programme would not permit the use of three prisms. Three-fourths of the observations and all the measurements were made by myself in order to avoid as far as possible any chance of systematic discrepancies.

*Potsdam Publications, Band VII., p. 146.

†Publications of the Yerkes Observatory, 2, 61.

‡Lick Observatory Bulletin No. 70.

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The star β Orionis is of the helium type, Miss Maury's V.L.e, and has fairly well defined lines of hydrogen and helium, the magnesium λ 4481 and the calcium H and K . It also contains lines due to silicon, oxygen and carbon and a few faint metallic lines. In my early measures for slit-width effect eight lines were measured in the three-prism plates and seven in the single-prism plates.

Lines measured in β Orionis.

| Three-Prism Plates. | One-Prism Plates. |
|---------------------|-------------------|
| 4862 <i>H</i> | 4862 <i>H</i> |
| 4481 <i>Mg</i> | 4481 <i>Mg</i> |
| 4472 <i>He</i> | 4472 <i>He</i> |
| 4388 <i>He</i> | 4341 <i>H</i> |
| 4341 <i>H</i> | 4102 <i>H</i> |
| 4131 <i>Si</i> | 4026 <i>He</i> |
| 4128 <i>Si</i> | 3934 <i>Ca</i> |
| 4102 <i>H</i> | |

It was found, however, that lower probable errors were obtained where the three best lines λ 4481, 4472, 4341 only were used than when more or all of the measured lines were discussed. Consequently in the later plates only the three lines mentioned above have been measured and in general four comparison lines, thus considerably lightening the labour. Considerable difference in the quality of the negatives for measurement, even when taken under, so far as could be judged, identical conditions, has been noticed; this difference seems to lie principally in the character of the lines themselves. They are sometimes sharply defined and symmetrical, at others not so sharp and apparently stronger at one side. Sometimes also the contrast between them and the continuous spectrum appears considerably diminished. These changes seem almost too marked to be due entirely to instrumental or photographic effects, and one would be inclined to attribute part at any rate to changes in the spectrum. No evidence can be found, however, of any dependence of this quality of the lines upon the phase of the orbit.

In the measurements the lines were weighted according to their apparent quality and the weighted mean velocity used. In combining the separate plates on each night they were also weighted, partly according to their quality and partly according to the internal agreement of the measures, and finally the resultant mean velocity for the night was similarly weighted for use in the grouping and discussion.

The record of the observations and the individual plate measures are given in Appendix E, where all the measures are collected together, while a summary of the velocities, &c., is given in the following table:—

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 β ORIONIS.

SUMMARY OF MEASURES.

| Plate Number. | Date. | G. M. T. | Julian Date. | Velocity. | Residual. | |
|---------------|---------------|----------|--------------|--------------|-----------|-------|
| 1908. | | | | | | |
| 1241 a. | January. | 20 | 15 02 | 2,417,961.63 | +23.3 | - 2.4 |
| 1241 b. | " | 20 | 15 06 | 961.63 | +20.9 | 0.0 |
| 1241 c. | " | 20 | 15 10 | 961.63 | +25.4 | + 4.5 |
| 1242 a. | " | 20 | 15 12 | 961.63 | +23.7 | - 2.8 |
| 1242 b. | " | 20 | 15 15 | 961.64 | +25.9 | + 5.0 |
| 1242 c. | " | 20 | 15 18 | 961.64 | +19.7 | - 1.2 |
| 1243 a. | " | 20 | 15 24 | 961.64 | +21.3 | + 0.4 |
| 1243 b. | " | 20 | 15 27 | 961.65 | +23.5 | + 2.6 |
| 1243 c. | " | 20 | 15 30 | 961.65 | +24.8 | + 3.9 |
| 1244 a. | " | 20 | 15 43 | 961.66 | +24.5 | + 3.6 |
| 1244 b. | " | 20 | 15 47 | 961.66 | +16.5 | - 4.4 |
| 1244 c. | " | 20 | 15 50 | 961.66 | +26.4 | + 5.5 |
| 1245 a. | " | 20 | 15 52 | 961.66 | +25.0 | + 4.1 |
| 1245 b. | " | 20 | 15 54 | 961.66 | +21.8 | + 0.9 |
| 1245 c. | " | 20 | 15 56 | 961.66 | +20.5 | - 0.4 |
| 1247 a. | " | 20 | 16 15 | 961.68 | +23.8 | - 2.9 |
| 1247 b. | " | 20 | 16 17 | 961.68 | +31.3 | +10.4 |
| 1247 c. | " | 20 | 16 19 | 961.68 | +19.0 | - 1.9 |
| 1248 a. | " | 20 | 16 25 | 961.68 | +11.6 | - 9.3 |
| 1248 b. | " | 20 | 16 27 | 961.68 | - 5.8 | -15.1 |
| 1248 c. | " | 20 | 16 29 | 961.68 | +36.1 | -15.2 |
| 1249 a. | " | 20 | 16 35 | 961.69 | +14.0 | - 6.9 |
| 1249 b. | " | 20 | 16 37 | 961.69 | +16.0 | - 4.9 |
| 1249 c. | " | 20 | 16 39 | 961.69 | +24.2 | - 3.3 |
| 1285 a. | " | 27 | 15 45 | 968.68 | +15.3 | - 5.8 |
| 1285 b. | " | 27 | 15 51 | 968.66 | +19.2 | - 1.9 |
| 1285 c. | " | 27 | 15 57 | 968.67 | +17.9 | - 3.2 |
| 1286 a. | " | 27 | 16 03 | 968.67 | +21.3 | + 0.2 |
| 1286 b. | " | 27 | 16 09 | 968.67 | +18.7 | - 2.4 |
| 1286 c. | " | 27 | 16 15 | 968.67 | +24.3 | + 3.2 |
| 1289 a. | " | 27 | 17 13 | 968.72 | +18.1 | - 3.0 |
| 1289 b. | " | 27 | 17 17 | 968.72 | -19.9 | - 2.3 |
| 1289 c. | " | 27 | 17 21 | 968.72 | +27.8 | - 6.6 |
| 1290 a. | " | 27 | 17 24 | 968.73 | +15.6 | - 5.6 |
| 1290 b. | " | 27 | 17 28 | 968.73 | +21.6 | - 0.4 |
| 1290 c. | " | 27 | 17 32 | 968.73 | +16.1 | - 5.1 |
| 1405. | March. | 20 | 11 51 | 2,418,021.50 | +23.1 | - 1.4 |
| 1406. | " | 20 | 12 07 | 021.50 | +24.3 | - 0.2 |
| 1407. | " | 20 | 12 21 | 021.51 | +21.4 | - 3.1 |
| 1408. | " | 20 | 12 32 | 021.52 | +24.9 | - 0.1 |
| 1409. | " | 20 | 12 46 | 021.53 | +28.0 | - 3.5 |
| 1410. | " | 20 | 13 00 | 021.54 | +23.3 | - 1.2 |
| 1411. | " | 20 | 13 12 | 021.55 | +23.5 | - 1.0 |
| 1412. | " | 20 | 13 27 | 021.56 | +24.9 | + 0.4 |
| 1413. | " | 20 | 13 47 | 021.57 | +27.5 | + 3.0 |
| 1414. | " | 20 | 13 57 | 021.58 | +26.9 | + 2.4 |
| 1426. | " | 24 | 12 03 | 025.50 | +19.2 | - 2.9 |
| 1427. | " | 24 | 12 15 | 025.51 | +21.1 | - 1.0 |
| 1428. | " | 24 | 12 23 | 025.52 | +19.2 | - 2.9 |
| 1429. | " | 24 | 12 36 | 025.52 | +21.6 | - 0.5 |
| 1430. | " | 24 | 12 42 | 025.53 | +18.8 | - 3.3 |
| 1431. | " | 24 | 12 52 | 025.53 | +18.6 | - 3.5 |
| 1433. | " | 24 | 13 16 | 025.55 | +17.5 | - 4.6 |
| 1434. | " | 24 | 13 32 | 025.56 | +19.3 | - 2.8 |
| 1435. | " | 24 | 13 39 | 025.57 | +16.1 | - 6.0 |
| 1436. | " | 24 | 13 46 | 025.57 | +17.2 | - 4.9 |
| 1437. | " | 24 | 13 56 | 025.58 | +18.7 | - 3.4 |
| 1438. | " | 24 | 14 07 | 025.58 | +18.0 | - 4.1 |
| 1439. | " | 30 | 12 19 | 031.51 | +14.4 | - 4.1 |
| 1440. | " | 30 | 12 29 | 031.52 | +14.4 | - 4.1 |
| 1441. | " | 30 | 12 38 | 031.53 | +14.5 | - 4.0 |
| 1442. | " | 30 | 12 49 | 031.53 | +17.0 | - 1.5 |
| 1448. | April. | 3 | 12 16 | 035.51 | +24.9 | + 1.5 |
| 1449. | " | 3 | 12 28 | 035.52 | +27.9 | + 4.5 |
| 1450. | " | 3 | 12 40 | 035.53 | +32.2 | + 8.7 |
| 1451. | " | 3 | 12 53 | 035.53 | +27.1 | + 3.6 |

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 β ORIONIS.

SUMMARY OF MEASURES—Continued.

| Plate Number. | Date. | G. M. T. | Julian Date. | Velocity. | Residual. |
|---------------|----------------------|----------|--------------|-----------|-----------|
| 1908. | | | | | |
| 1457 | April 4 | 12 19 | 2,418,036 51 | +29.9 | +5.0 |
| 1458 | " 4 | 12 28 | 036 52 | +27.4 | +2.5 |
| 1459 | " 4 | 12 37 | 036 53 | +27.0 | +2.1 |
| 1469 | " 13 | 12 10 | 045 51 | +21.3 | -2.0 |
| 1470 | " 13 | 12 22 | 045 52 | +25.0 | +1.7 |
| 1471 | " 13 | 12 34 | 045 52 | +24.8 | +1.5 |
| 1873 | September . . . 7 | 21 52 | 192 92 | +28.2 | +2.2 |
| 1874 | " 7 | 22 10 | 192 93 | +27.1 | +1.1 |
| 1935 | October 13 | 21 19 | 228 90 | +18.3 | -0.2 |
| 1936 | " 13 | 21 48 | 228 91 | +17.0 | -1.5 |
| 1937 | " 13 | 22 19 | 228 93 | +17.5 | -1.0 |
| 1938 | " 13 | 22 47 | 228 95 | +14.3 | -4.2 |
| 1978 | November . . . 21 | 18 24 | 267 77 | +17.0 | -4.2 |
| 1979 | " 21 | 18 43 | 267 78 | +17.3 | -3.9 |
| 1980 | " 21 | 19 05 | 267 79 | +24.5 | +3.3 |
| 1981 | " 21 | 19 33 | 267 81 | +25.0 | +3.8 |
| 1984 | " 28 | 16 05 | 274 67 | +21.0 | +0.9 |
| 1985 | " 28 | 16 34 | 274 69 | +22.7 | +2.6 |
| 1986 | " 28 | 17 08 | 274 71 | +20.5 | +0.4 |
| 1987 | December . . . 1 | 17 53 | 277 75 | +16.4 | -8.9 |
| 1988 | " 1 | 18 18 | 277 76 | +20.9 | -4.4 |
| 1989 | " 1 | 18 36 | 277 77 | +16.1 | -9.2 |
| 1990 | " 1 | 18 52 | 277 78 | +23.1 | -2.2 |
| 2003 | " 5 | 16 10 | 281 67 | +22.6 | -3.1 |
| 2004 | " 5 | 16 22 | 281 68 | +25.1 | -0.6 |
| 2005 | " 5 | 16 38 | 281 69 | +25.6 | -0.1 |
| 2006 | " 5 | 16 53 | 281 70 | +27.5 | +0.8 |
| 2054 | " 21 | 15 24 | 297 64 | +21.5 | -0.6 |
| 2055 | " 21 | 15 29 | 297 65 | +21.9 | -0.2 |
| 2057 | " 21 | 16 54 | 297 70 | +25.7 | +3.6 |
| 2058 | " 21 | 17 00 | 297 71 | +22.0 | -0.1 |
| 2065 | " 22 | 17 38 | 298 73 | +28.1 | +4.0 |
| 2066 | " 22 | 17 52 | 298 74 | +21.7 | -2.4 |
| 2067 | " 22 | 18 02 | 298 75 | +23.1 | -1.0 |
| 2068 | " 22 | 18 14 | 298 76 | +23.2 | -0.9 |
| 2070 | " 23 | 14 01 | 2 9 58 | +20.9 | -4.3 |
| 2071 | " 23 | 14 41 | 299 61 | +26.8 | +1.6 |
| 2072 | " 23 | 15 08 | 299 63 | +23.5 | -1.7 |
| 2073 | " 23 | 15 20 | 299 64 | +21.2 | -4.0 |
| 2075 | " 26 | 15 50 | 302 66 | +25.6 | -0.4 |
| 2076 | " 26 | 16 00 | 302 67 | +25.9 | -0.1 |
| 2077 | " 26 | 16 09 | 302 67 | +22.5 | -3.5 |
| 2078 | " 26 | 16 18 | 302 68 | +22.0 | -4.0 |
| 2079 | " 27 | 14 07 | 303 59 | +33.2 | +7.6 |
| 2080 | " 27 | 15 12 | 303 64 | +29.7 | +4.1 |
| 2082 | " 31 | 15 19 | 307 64 | +22.7 | -1.0 |
| 2083 | " 31 | 15 23 | 307 64 | +24.7 | +1.0 |
| 2084 | " 31 | 15 29 | 307 65 | +23.0 | -0.7 |
| 2085 | " 31 | 15 57 | 307 67 | +20.5 | +2.8 |
| 1909. | | | | | |
| 2092 | January . . . 6 | 16 49 | 2,418,313 70 | +19.1 | -0.7 |
| 2093 | " 6 | 16 53 | 313 70 | +19.6 | -0.2 |
| 2094 | " 6 | 17 13 | 313 72 | +18.5 | -1.3 |
| 2095 | " 6 | 17 16 | 313 72 | +21.2 | +1.4 |
| 2105 | " 7 | 12 49 | 314 53 | +16.8 | -2.4 |
| 2106 | " 7 | 13 01 | 314 54 | +21.9 | +2.7 |
| 2107 | " 7 | 13 04 | 314 54 | +12.8 | -7.1 |
| 2108 | " 7 | 13 07 | 314 54 | +20.7 | +1.5 |
| 2111 | " 7 | 16 27 | 314 69 | +19.2 | 0.0 |
| 2112 | " 7 | 16 37 | 314 69 | +16.6 | -2.6 |
| 2114 | " 7 | 16 56 | 314 71 | +17.8 | -1.4 |
| 2117 | " 8 | 15 48 | 315 66 | +18.9 | +0.2 |
| 2118 | " 8 | 15 52 | 315 66 | +20.3 | +1.6 |
| 2122 | " 12 | 11 55 | 319 50 | +26.5 | +4.5 |
| 2123 | " 12 | 11 59 | 319 50 | +26.0 | +4.0 |

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BORIONIS.

SUMMARY OF MEASURES—Continued.

| Plate Number. | Date. | G. M. T. | Julian Date. | Velocity. | Residual. |
|---------------|---------------|----------|--------------|-----------|-----------|
| 1909. | | | | | |
| 2124..... | January... 12 | 12 09 | 2,418,319.51 | +20.5 | -1.5 |
| 2125..... | " 12 | 12 12 | 319.51 | -21.3 | -0.7 |
| 2126..... | " 12 | 12 15 | 319.51 | +27.2 | +5.0 |
| 2127..... | " 12 | 12 18 | 319.51 | -25.5 | +3.5 |
| 2128..... | " 13 | 15 36 | 320.65 | +30.2 | +6.1 |
| 2129..... | " 13 | 15 41 | 320.65 | +15.7 | -8.4 |
| 2130..... | " 13 | 15 46 | 320.66 | -28.8 | +4.7 |
| 2141..... | " 15 | 14 54 | 322.62 | +18.6 | +7.3 |
| 2142..... | " 15 | 15 11 | 322.63 | -24.5 | -1.4 |
| 2143..... | " 15 | 15 15 | 322.63 | -27.2 | +1.3 |
| 2144..... | " 15 | 15 19 | 322.64 | -21.8 | -4.1 |
| 2151..... | " 16 | 12 25 | 323.52 | +31.4 | +5.3 |
| 2152..... | " 16 | 12 36 | 323.52 | +27.6 | +1.5 |
| 2153..... | " 16 | 12 44 | 323.53 | -34.4 | +8.3 |
| 2154..... | " 16 | 12 52 | 323.53 | -40.9 | +14.8 |
| 2155..... | " 16 | 12 59 | 323.54 | +33.0 | +6.9 |
| 2156..... | " 16 | 13 12 | 323.55 | -35.8 | +9.7 |
| 2157..... | " 17 | 13 48 | 324.57 | +29.9 | +3.9 |
| 2158..... | " 17 | 13 56 | 324.58 | +26.2 | +0.2 |
| 2161..... | " 18 | 12 41 | 325.53 | -37.1 | +11.5 |
| 2162..... | " 18 | 12 46 | 325.53 | +31.3 | +5.7 |
| 2163..... | " 18 | 12 51 | 325.53 | -28.3 | +2.7 |
| 2164..... | " 18 | 13 06 | 325.54 | +35.8 | +10.2 |
| 2165..... | " 18 | 13 10 | 325.55 | +31.2 | +5.6 |
| 2166..... | " 18 | 13 14 | 325.55 | +30.5 | +4.9 |
| 2177..... | " 26 | 10 36 | 333.44 | +24.6 | +3.4 |
| 2178..... | " 26 | 10 51 | 333.45 | -17.8 | -3.4 |
| 2179..... | " 26 | 10 56 | 333.46 | +24.9 | +3.7 |
| 2180..... | " 26 | 11 01 | 333.46 | -23.5 | +2.3 |
| 2181..... | " 26 | 11 11 | 333.47 | +22.4 | +1.2 |
| 2182..... | " 26 | 11 16 | 333.47 | +16.2 | -5.0 |
| 2183..... | " 26 | 11 21 | 333.47 | -20.5 | -0.7 |
| 2184..... | " 28 | 11 21 | 335.47 | -16.3 | 3.6 |
| 2185..... | " 28 | 11 25 | 335.48 | +22.2 | +3.3 |
| 2186..... | " 28 | 11 29 | 335.48 | +14.2 | -5.7 |
| 2187..... | " 28 | 11 41 | 335.48 | +14.3 | -5.6 |
| 2188..... | " 28 | 11 44 | 335.49 | +10.6 | -9.3 |
| 2189..... | " 28 | 11 47 | 335.49 | +18.4 | -0.9 |
| 2195..... | " 29 | 12 53 | 336.54 | +14.9 | -4.3 |
| 2196..... | " 29 | 12 57 | 336.54 | +17.9 | -1.3 |
| 2197..... | " 29 | 13 01 | 336.54 | +26.4 | +7.2 |
| 2198..... | " 29 | 13 05 | 336.54 | +22.1 | +2.9 |
| 2201..... | " 30 | 12 29 | 337.52 | +14.0 | -4.7 |
| 2202..... | " 30 | 12 41 | 337.53 | +17.3 | -1.4 |
| 2203..... | " 30 | 12 45 | 337.53 | +25.0 | +6.3 |
| 2204..... | " 30 | 12 48 | 337.53 | +14.2 | -4.5 |
| 2205..... | " 30 | 15 47 | 337.66 | +21.0 | +2.3 |
| 2206..... | " 30 | 16 04 | 337.67 | +22.6 | +4.1 |
| 2207..... | " 30 | 16 24 | 337.68 | +22.3 | +3.8 |
| 2211..... | " 31 | 17 16 | 338.72 | +19.8 | +1.2 |
| 2212..... | " 31 | 17 20 | 338.72 | +23.2 | +4.6 |
| 2213..... | " 31 | 17 24 | 338.73 | +16.6 | -2.6 |
| 2214..... | " 31 | 17 29 | 338.73 | +16.6 | -2.0 |
| 2215..... | February 2 | 11 14 | 340.47 | +24.8 | +4.6 |
| 2216..... | " 2 | 11 23 | 340.48 | +23.1 | +2.9 |
| 2217..... | " 2 | 11 26 | 340.48 | +23.6 | +3.4 |
| 2218..... | " 2 | 11 29 | 340.48 | +22.5 | +2.3 |
| 2219..... | " 2 | 11 41 | 340.49 | +16.5 | -3.7 |
| 2220..... | " 2 | 11 45 | 340.49 | +21.5 | +1.3 |
| 2236..... | " 6 | 12 29 | 344.52 | +18.2 | -7.7 |
| 2239..... | " 6 | 12 50 | 344.53 | +20.0 | -5.9 |
| 2240..... | " 6 | 12 52 | 344.53 | +21.0 | -4.9 |
| 2241..... | " 6 | 16 12 | 344.68 | +21.9 | -4.0 |
| 2242..... | " 6 | 16 43 | 344.70 | +19.1 | -6.8 |
| 2243..... | " 7 | 15 11 | 345.63 | +21.0 | -5.1 |
| 2244..... | " 7 | 15 25 | 345.64 | +21.9 | -4.2 |

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 β ORIONIS.SUMMARY OF MEASURES. — *Continued.*

| Plate Number. | Date. | G. M. T. | Julian Date. | Velocity. | Residual. |
|---------------|--------------|----------|--------------|-----------|-----------|
| 1909. | | | | | |
| 2245 | February.. 7 | 15:37 | 2,418,345.65 | +18.0 | - 8.1 |
| 2249 | " 8 | 13:32 | 346.56 | +31.6 | + 5.2 |
| 2250 | " 8 | 13:36 | 346.56 | +25.9 | 0.0 |
| 2251 | " 8 | 13:41 | 346.57 | +21.8 | - 4.1 |
| 2252 | " 8 | 14:01 | 346.58 | +17.6 | - 8.3 |
| 2253 | " 8 | 14:05 | 346.58 | +24.1 | - 1.8 |
| 2254 | " 8 | 14:09 | 346.59 | +23.3 | - 2.6 |
| 2265 | " 10 | 12:07 | 348.50 | +29.6 | + 4.4 |
| 2266 | " 10 | 12:12 | 348.51 | +23.3 | - 1.9 |
| 2267 | " 10 | 12:16 | 348.51 | +16.9 | - 8.3 |
| 2268 | " 10 | 12:21 | 348.51 | +12.8 | -12.4 |
| 2269 | " 10 | 12:33 | 348.52 | +20.3 | - 4.9 |
| 2270 | " 10 | 12:37 | 348.53 | +23.0 | - 2.2 |
| 2272 | " 11 | 11:26 | 349.48 | +18.9 | - 5.8 |
| 2273 | " 11 | 11:32 | 349.48 | +33.4 | + 8.7 |
| 2274 | " 11 | 11:35 | 349.48 | +30.8 | + 6.1 |
| 2275 | " 11 | 11:38 | 349.49 | +19.7 | - 5.0 |
| 2276 | " 11 | 11:46 | 349.49 | +17.3 | - 7.4 |
| 2277 | " 11 | 11:49 | 349.49 | +23.5 | - 1.2 |
| 2278 | " 13 | 12:27 | 351.52 | +22.2 | - 1.4 |
| 2279 | " 13 | 12:49 | 351.53 | +22.0 | - 1.6 |
| 2280 | " 13 | 12:53 | 351.54 | +21.1 | - 2.2 |
| 2284 | " 20 | 12:29 | 358.52 | +17.7 | - 1.4 |
| 2285 | " 20 | 13:05 | 358.54 | +22.6 | + 3.5 |
| 2286 | " 20 | 15:12 | 358.63 | +19.8 | + 0.7 |
| 2288 | " 21 | 12:51 | 359.53 | +21.0 | + 2.3 |
| 2289 | " 21 | 13:07 | 359.54 | +18.2 | - 0.5 |
| 2290 | " 21 | 13:17 | 359.55 | +18.4 | - 0.3 |
| 2291 | " 21 | 13:27 | 359.56 | +18.7 | 0.0 |
| 2292 | " 22 | 12:02 | 360.50 | +19.7 | + 1.1 |
| 2293 | " 22 | 12:15 | 360.51 | +25.1 | + 6.5 |
| 2294 | " 22 | 12:30 | 360.52 | +20.2 | + 1.6 |
| 2295 | " 22 | 12:45 | 360.53 | +20.2 | + 1.6 |
| 2309 | " 27 | 11:35 | 365.48 | +22.0 | - 3.4 |
| 2311 | " 28 | 11:56 | 366.50 | +22.2 | - 3.8 |
| 2312 | " 28 | 12:07 | 366.50 | +22.0 | - 4.0 |
| 2313 | " 28 | 12:18 | 366.51 | +23.7 | - 2.3 |
| 2314 | " 28 | 12:27 | 366.52 | +25.3 | - 0.7 |
| 2315 | " 28 | 12:39 | 366.53 | +22.4 | - 3.6 |
| 2316 | " 28 | 12:50 | 366.53 | +22.8 | - 3.2 |
| 2317 | March..... 2 | 11:06 | 368.46 | +25.9 | 0.0 |
| 2318 | " 2 | 11:19 | 368.47 | +24.4 | - 1.5 |
| 2319 | " 2 | 11:29 | 368.48 | +24.2 | - 1.7 |
| 2320 | " 3 | 11:36 | 368.48 | +21.6 | - 4.3 |
| 2364 | " 13 | 12:12 | 379.51 | +18.6 | - 1.1 |
| 2365 | " 13 | 12:24 | 379.52 | +18.4 | - 1.3 |
| 2366 | " 13 | 12:36 | 379.52 | +20.3 | + 0.6 |
| 2367 | " 13 | 12:46 | 379.53 | +17.6 | - 2.1 |
| 2368 | " 13 | 12:57 | 379.54 | +19.3 | - 0.4 |
| 2372 | " 15 | 11:45 | 381.49 | +16.9 | - 1.8 |
| 2373 | " 15 | 11:56 | 381.50 | +20.5 | + 1.8 |
| 2374 | " 15 | 12:05 | 381.50 | +17.6 | - 1.1 |
| 2375 | " 15 | 12:13 | 381.51 | +18.9 | + 0.2 |
| 2376 | " 15 | 12:21 | 381.52 | +16.2 | - 2.5 |
| 2386 | " 18 | 11:42 | 384.49 | +19.5 | - 1.1 |
| 2387 | " 18 | 11:52 | 384.50 | +20.0 | - 0.6 |
| 2388 | " 18 | 12:02 | 384.50 | +21.7 | + 1.1 |
| 2389 | " 18 | 12:12 | 384.51 | +21.0 | + 0.4 |
| 2390 | " 20 | 12:16 | 386.51 | +22.2 | - 2.1 |
| 2391 | " 20 | 12:26 | 386.52 | +18.3 | - 6.0 |
| 2392 | " 20 | 12:38 | 386.53 | +23.4 | - 0.9 |
| 2393 | " 20 | 12:48 | 386.53 | +21.9 | - 2.4 |
| 2394 | " 20 | 12:58 | 386.54 | +23.1 | - 1.2 |
| 2397 | " 21 | 13:38 | 387.56 | +23.9 | - 1.6 |
| 2398 | " 21 | 13:48 | 387.57 | +25.2 | - 0.3 |
| 2399 | " 21 | 14:00 | 387.58 | +24.8 | - 0.7 |

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 β ORIONIS.

SUMMARY OF MEASURES—Continued.

| Plate Number. | Date. | G.M.T. | Julian Date. | Velocity. | Residual. |
|---------------|---------------|--------|--------------|-----------|-----------|
| | 1909. | | | | |
| 2400..... | March 21 | 14 14 | 2,418,387.59 | +25.5 | 0.0 |
| 2402..... | " 22 | 11 51 | 388.49 | +26.0 | 0.0 |
| 2403..... | " 22 | 12 02 | 388.50 | +25.0 | - 1.0 |
| 2404..... | " 22 | 12 13 | 388.51 | +21.1 | - 4.9 |
| 2405..... | " 22 | 12 35 | 368.52 | +21.2 | - 4.8 |
| 2420..... | " 23 | 11 46 | 389.49 | +23.1 | - 3.0 |
| 2421..... | " 23 | 11 57 | 389.50 | -24.4 | - 1.7 |
| 2422..... | " 23 | 12 05 | 389.50 | -25.9 | - 0.2 |
| 2423..... | " 23 | 12 13 | 389.51 | +26.2 | + 0.1 |
| 2424..... | " 23 | 12 27 | 389.52 | -25.5 | - 0.6 |
| 2425..... | " 23 | 12 38 | 389.53 | +25.7 | - 0.4 |

In the preceding table are given the plate number, the Greenwich mean and Julian dates, the weighted mean velocity for the plate, and finally the residual obtained by scaling from the final velocity curve. The velocities on each night were obtained by taking the weighted means of the plate velocities, the weights being assigned, as before stated, partly on the basis of apparent quality, partly according to the internal agreement of the measures. In the following table of mean velocities are given various data concerning the observations of each night, as the date, Julian date, velocity, phase, the number of plates, the dispersion used, the weight assigned and finally the residual obtained by scaling from the curve:—

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 β ORIONIS.

SUMMARY OF MEAN VELOCITIES PER NIGHT.

| Date. | Julian Date. | Mean Velocity. | Mean Phase. | No. of Plates. | Spectro-graph. | Weight. | Residual. |
|--------------|--------------|----------------|-------------|----------------|----------------|---------|-----------|
| 1908. | | | | | | | |
| Jan. 20.... | 2,417,961.65 | 22.3 | 0.65 | 24 | I L | 16 | +1.40 |
| " 27.... | 968.71 | 19.7 | 7.71 | 12 | III S | 6 | -1.50 |
| March 20.... | 2,418,021.54 | 24.9 | 16.74 | 10 | III L | 10 | +0.45 |
| " 24.... | 025.54 | 20.6 | 20.74 | 12 | " | 6 | -1.47 |
| " 30.... | 031.52 | 15.1 | 4.82 | 4 | " | 6 | -3.46 |
| April 3.... | 035.52 | 27.3 | 8.82 | 4 | " | 4 | +3.87 |
| " 4.... | 036.52 | 28.2 | 9.82 | 3 | " | 3 | +3.28 |
| " 13.... | 045.52 | 24.2 | 18.82 | 3 | " | 3 | +0.93 |
| Sept. 7.... | 192.92 | 27.1 | 12.92 | 2 | " | 2 | +1.10 |
| Oct. 13.... | 228.92 | 16.8 | 5.12 | 4 | " | 5 | -1.76 |
| Nov. 21.... | 267.79 | 22.3 | 0.19 | 4 | " | 3 | +1.08 |
| " 28.... | 274.69 | 21.4 | 7.09 | 3 | " | 2 | +1.32 |
| Dec. 1.... | 277.77 | 20.1 | 10.17 | 4 | " | 1 | -5.19 |
| " 5.... | 281.69 | 25.9 | 14.09 | 4 | " | 2 | -1.36 |
| " 21.... | 297.68 | 23.0 | 8.18 | 4 | I L | 2 | +0.85 |
| " 22.... | 298.75 | 24.0 | 9.25 | 4 | III L | 2 | -0.10 |
| " 23.... | 299.63 | 23.8 | 10.13 | 4 | " | 2 | -1.43 |
| " 26.... | 302.67 | 24.6 | 13.17 | 4 | " | 3 | -1.36 |
| " 27.... | 303.65 | 31.4 | 14.15 | 2 | " | 2 | +5.77 |
| " 31.... | 307.65 | 24.2 | 18.15 | 4 | I L | 2 | +0.56 |
| 1909. | | | | | | | |
| Jan. 6.... | 313.71 | 19.6 | 2.31 | 4 | I L | 2 | -0.20 |
| " 7.... | 314.62 | 17.9 | 3.22 | 7 | I & III | 4 | -1.34 |
| " 8.... | 315.66 | 19.6 | 4.26 | 2 | I L | 1 | +0.87 |
| " 12.... | 319.50 | 24.7 | 8.10 | 6 | " | 3 | +2.70 |
| " 13.... | 320.66 | 24.9 | 9.26 | 3 | " | 1 | +0.77 |
| " 15.... | 322.62 | 24.0 | 11.22 | 4 | " | 1 | -1.93 |
| " 16.... | 323.53 | 33.4 | 12.13 | 6 | " | 3 | +7.30 |
| " 17.... | 324.57 | 28.1 | 13.17 | 2 | " | 1 | +2.15 |
| " 18.... | 325.54 | 32.4 | 14.14 | 6 | " | 3 | +6.78 |
| " 26.... | 333.47 | 21.3 | 0.17 | 7 | " | 4 | +0.08 |
| " 28.... | 335.49 | 16.7 | 2.19 | 6 | " | 2 | -3.18 |
| " 29.... | 336.54 | 19.7 | 3.24 | 4 | " | 1 | +0.46 |
| " 30.... | 337.61 | 20.0 | 4.31 | 7 | I & III | 5 | +1.28 |
| " 31.... | 338.72 | 18.3 | 5.42 | 4 | I L | 2 | -0.29 |
| Feb. 2.... | 340.49 | 21.5 | 7.19 | 6 | " | 4 | +1.30 |
| " 6.... | 344.59 | 20.7 | 11.29 | 5 | I & III | 3 | -5.26 |
| " 7.... | 345.64 | 20.0 | 12.34 | 3 | III L | 2 | -6.08 |
| " 8.... | 346.57 | 24.7 | 13.27 | 6 | I L | 2 | -1.23 |
| " 10.... | 348.52 | 21.0 | 15.22 | 6 | " | 1 | -4.17 |
| " 11.... | 349.49 | 23.9 | 16.19 | 6 | " | 1 | -0.83 |
| " 13.... | 351.53 | 21.9 | 18.23 | 3 | III L | 3 | -1.71 |
| " 20.... | 358.57 | 19.4 | 3.37 | 3 | " | 2 | -0.36 |
| " 21.... | 359.55 | 19.2 | 4.35 | 4 | " | 3 | +0.49 |
| " 22.... | 360.52 | 20.0 | 5.32 | 4 | " | 3 | +1.43 |
| " 27.... | 365.48 | 22.0 | 10.28 | 1 | " | 1 | -3.38 |
| " 28.... | 366.53 | 22.8 | 11.33 | 6 | " | 4 | -3.18 |
| March 2.... | 368.47 | 23.4 | 13.27 | 4 | " | 2 | -2.52 |
| " 13.... | 379.53 | 18.8 | 2.43 | 5 | " | 5 | -0.91 |
| " 15.... | 381.50 | 18.0 | 4.40 | 5 | " | 3 | -0.68 |
| " 18.... | 384.50 | 20.55 | 7.40 | 4 | " | 3 | -0.04 |
| " 20.... | 386.53 | 22.2 | 9.43 | 5 | " | 4 | -2.15 |
| " 21.... | 387.57 | 24.85 | 10.47 | 4 | " | 3 | -0.68 |
| " 22.... | 388.51 | 23.3 | 11.41 | 4 | " | 2 | -2.69 |
| " 23.... | 389.51 | 25.1 | 12.41 | 6 | " | 4 | -0.97 |

It was not difficult to trace periodic changes in the velocities thus determined, and comparatively early in the present season the period was found to be very nearly 21.90 days. The Potsdam observations, however, did not group themselves satisfactorily with this period, and owing to their probably inferior accuracy were not considered. The Yerkes observations showed a fairly satisfactory arrangement, although there were some discrepant single plates, due possibly to accidental errors of setting on the rather

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broad lines of the spectrum, or to another cause to be referred to later on. The Lick observations, extending over seven years, followed the velocity curve determined as closely as could be expected, although as there are only five plates this agreement may be accidental. It was found, however, that a period of 21.87 instead of 21.90 days was required to bring the Lick observations forward to ours.

Although some discrepancies are to be expected on account of the small range in velocity and the relatively high errors of measurement, still it was felt that all the irregularities noted could not be explained on the above grounds. Consequently, although sufficient evidence had been secured of the binary character of β Orionis and sufficient data to obtain the elements of the orbit by the end of January, it was deemed desirable to continue the observations in the hope of finding a clue to some of the anomalies. The later observations revealed some peculiar and interesting features in the star's motion which served, if not to explain the cause of the irregularities, at least to indicate a reason for their existence.

The phase of minimum velocity due January 30-31 followed prediction, but the succeeding maximum, due February 6-7, although present, was of much lower amplitude than those previously obtained. The curve already drawn showed a range of velocity between about +17 and +29km. The maximum of February 6 reached only about 23km., and the succeeding minima and maxima until the end of the observations were as follows:—+ 19.5, + 23.0; + 18.5, + 24.5; 19.0, + 24.5. All of these values, as well as the previous ones, depend upon several plates, and there is no doubt in my mind that they indicate, if not a change in the amplitude of the velocity curve, certainly some progressive shift in the position of the absorption maximum of the lines measured due to some physical cause in the star's atmosphere. If it is a change in the amplitude of the motion, it may be due to the presence of a third body and will probably be periodic. If an epoch of low amplitude occurred in 1901-1902 this, together with the fact of their only making one plate per night and the consequently higher accidental errors, would form a sufficient explanation why Frost and Adams with the high accuracy of their work were unable to find any periodicity in the motion. Furthermore, a change in the amplitude is probably accompanied by changes in the other elements of the orbit, which may account for the slight change in the period requisite when the Lick observations are brought up to the same epoch as those at Ottawa.

If all the Ottawa observations are plotted continuously on cross-section paper, they form a curve somewhat similar to the trace given by two beating tuning forks. It shows curves similar to the velocity curve of Fig. (16) periodically repeated with gradually increasing amplitude, then with a sudden diminution followed by another gradual increase. The observations have not been sufficiently continuous or extended to decide whether this variation in amplitude is periodic, and in any case the very small range combined with the comparatively poor quality of the spectrum for measurement would render such a determination difficult and uncertain even if a very large number of plates were obtained.

I have, therefore, thought it preferable now, as all these successive curves have, so far as can be determined, the same form, to consider the variations in amplitude as accidental or, if you like, as due to errors in measurement; and to obtain a mean curve and from it the elements of the orbit by grouping together into normal places the mean velocities obtained on the 54 nights under discussion. The period chosen was that mentioned above, 21.90 days, which best suited our own and the Lick observations and which under the conditions cannot probably be improved upon. The initial phase T_0 was taken as Julian day 2,417,961.0. The basis of grouping into the normal places was the phase, the total difference in phase in the nights in a group being kept generally less than half a day, except in three groups where the velocity changes but slowly.

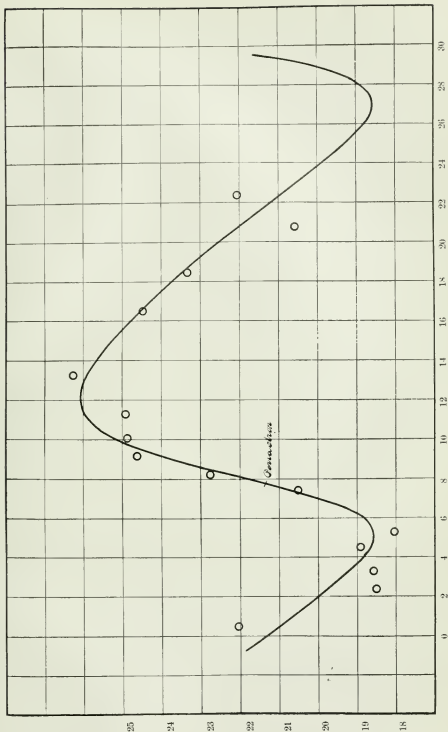


FIG. 16—Velocity Curve of β Orionis.

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These normal places with other data are given in the table below, and the places themselves are indicated by circles on the velocity curve Fig. (16) corresponding to the final elements.

NORMAL PLACES β ORIONIS.

| No. | Mean velocity. | Mean phase. | No. of nights. | No. of plates. | Total diff. of phase. | Weight. | Weight used in solution. | Residual O-C |
|-----|----------------|-------------|----------------|----------------|-----------------------|---------|--------------------------|--------------|
| 1 | 22.06 | 0.444 | 3 | 35 | 0.48 | 17 | 0.95 | +1.02 |
| 2 | 18.51 | 2.350 | 3 | 15 | 0.24 | 9 | | -1.24 |
| 3 | 18.59 | 3.266 | 3 | 14 | 0.15 | 7 | | -0.60 |
| 4 | 18.92 | 4.481 | 5 | 22 | 0.59 | 17 | | +0.27 |
| 5 | 18.06 | 5.240 | 3 | 12 | 0.30 | 10 | | -0.47 |
| 6 | 20.51 | 7.427 | 4 | 25 | 0.62 | 15 | | -0.10 |
| 7 | 22.76 | 8.200 | 2 | 10 | 0.27 | 5 | | +0.61 |
| 8 | 24.63 | 9.160 | 4 | 16 | 0.63 | 11 | | +0.65 |
| 9 | 24.90 | 10.024 | 4 | 10 | 0.46 | 7 | | -0.26 |
| 10 | 24.91 | 11.265 | 6 | 31 | 1.66 | 16 | | -1.10 |
| 11 | 26.28 | 13.253 | 10 | 39 | 1.81 | 23 | | +0.34 |
| 12 | 24.49 | 16.567 | 3 | 22 | 1.52 | 12 | | -0.05 |
| 13 | 23.34 | 18.431 | 3 | 10 | 0.67 | 8 | | -0.17 |
| 14 | 20.60 | 20.740 | 1 | 12 | 0.00 | 6 | | -1.48 |

With these normal places and by the graphical method developed by you, described in last year's report, the elements given below were readily determined, with which the observations seemed to agree closely. However, owing to the considerable differences in the weight of the normal places, which could not very well be allowed for in a graphical solution, and to the advantages demonstrated by previous experience, it was felt desirable to apply a least squares correction to these elements.

For coefficients of the corrections the equations developed by Lehmann-Filhés* were used, and from these and from the ephemeris obtained from the normal places and preliminary elements, the following observation equations were derived. All of the elements except the period, which was considered as closely determined as possible from the range of velocity present and the short interval used, were included in this solution and an unknown of coefficient unity for the velocity of the system was added.

OBSERVATION EQUATIONS β ORIONIS.

| x | μ | κ | u | v | Γ | Weight. | s |
|----------------|------------|-----------------|-------------|--|----------|---------|--------|
| $\delta\gamma$ | δK | $K\delta\omega$ | $K\delta e$ | $\frac{K\mu\delta T}{(1-e^2)^{\frac{3}{2}}}$ | | | |
| 1.000 | -0.505 | -0.698 | +0.892 | +0.892 | -1.51 | 0.95 | -0.071 |
| " | -0.851 | -0.408 | -0.859 | -0.601 | -0.74 | | -1.937 |
| " | -0.975 | -0.190 | +0.523 | -0.384 | -0.20 | | -0.942 |
| " | -1.052 | +0.178 | -0.223 | -0.015 | -0.42 | | -0.507 |
| " | -1.020 | +0.443 | -0.528 | -0.249 | +0.56 | | -0.206 |
| " | -0.464 | +1.104 | -0.598 | -0.911 | +0.19 | | -0.325 |
| " | -0.138 | +1.189 | +0.140 | -0.996 | -0.83 | | +0.365 |
| " | +0.267 | +1.141 | -0.924 | -0.948 | -1.18 | | +1.204 |
| " | +0.569 | +0.977 | +0.845 | -0.784 | -0.33 | | +2.277 |
| " | +0.876 | +0.565 | +0.519 | -0.372 | +0.80 | | +3.388 |
| " | +0.941 | +0.071 | -0.486 | +0.122 | -0.31 | | +1.338 |
| " | +0.588 | -0.575 | -0.869 | -0.774 | -0.16 | | +1.078 |
| " | -0.267 | -0.755 | -1.366 | -0.948 | -0.10 | | -0.194 |
| " | -0.183 | -0.798 | -0.460 | -0.991 | -1.16 | | +2.630 |

* A. N., No. 3242.

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From these observation equations the following normal equations were obtained:—

$$\begin{aligned} 6\ 833x - 0\ 558y + 1\ 110z - 0\ 041u - 0\ 213v - 1\ 132=0 \\ - 0\ 558x + 3\ 755y + 0\ 085z - 0\ 466u - 0\ 192v + 0\ 185=0 \\ + 1\ 110x + 0\ 085y + 3\ 284z + 0\ 192u - 3\ 072v - 0\ 211=0 \\ - 0\ 041x - 0\ 466y + 0\ 192z + 3\ 363u - 0\ 202v - 1\ 192=0 \\ + 0\ 213x - 0\ 192y - 3\ 072z - 0\ 202u - 3\ 118v - 0\ 009=0 \end{aligned}$$

From the elimination there resulted the following values of the unknowns with their probable errors:—

$$\begin{aligned} x \text{ or } \delta\gamma &= +\ 1721 & \pm\ 1584 \\ y \text{ or } \delta K &= +\ 0212 & \pm\ 2096 \\ z \text{ or } K\delta\omega &= -\ 0157 & \delta\omega = -\ 0042 = -\ 0\ 24' \pm 3\ 48'' \\ u \text{ or } K\delta\epsilon &= +\ 3604 & \delta\epsilon = +\ 0961 \pm 0587 \\ & K\mu\delta T \\ & \text{or } \frac{K\mu\delta T}{(1-\epsilon^2)^{\frac{3}{2}}} = 0 & \delta T = 0 \end{aligned}$$

When these are applied to the preliminary values we obtain:

ELEMENTS OF β ORIONIS.

| Name. | Symbol. | Preliminary. | Corrected. |
|------------------------------|------------|--------------|-----------------------------------|
| Eccentricity..... | e | 0.20 | $0\ 296 \pm 059$ |
| Half-Amplitude..... | K | 3.75 | $3\ 771 \pm 210\ \text{km.}$ |
| Longitude of Apse..... | ω | 255° | $254^\circ\ 76' \pm 3'\ 48''$ |
| Periastron Passage..... | T | 7.80 | J. D. 2,417,968.80 |
| Period..... | U | 21.90 | 21.90 dys. |
| Velocity of System..... | γ | -22.444 | $\pm 22\ 616 \pm 158\ \text{km.}$ |
| Projection of Semi-axis..... | $a \sin i$ | 1,100,500 | 1,108,900 km. |
| Maximum Velocity..... | N_1 | +26.0 | -26.09 km. |
| Minimum Velocity..... | N_2 | -18.5 | -18.55 km. |

It will be noticed that except for the eccentricity the changes in the elements are very small and a comparison between the residuals from the corrected ephemeris and from substitution in the observation equations shows that the solution is satisfactory enough, as there are none greater than .25km. It was not deemed necessary to make a second solution considering the assumptions made in combining the observations. That the solution has improved the elements was shown at once on comparing the curves and is also evident by the reduction of Σprv from 3.88 to 3.16.

The probable error of a normal place of unit weight is $\pm 0.40\text{km.}$ The probable error of a night obtained by scaling from the curve is ± 1.80 . The probable error of a plate obtained with a dispersion of three prisms is $\pm 1.98\text{km.}$ with dispersion of one prism $\pm 3.22\text{km.}$ and including all the plates $\pm 2.62\text{km.}$ If, as was done, the observations are divided into two sets—those before and those after January 29, 1909, when the sudden change in amplitude was noticed—and separate curves and elements are obtained roughly for these sets, the probable error of a night reduces to $\pm 1.37\text{km.}$ with a proportional reduction in the probable errors of single plates, and this would probably be not much greater than 1km. if the amplitude remained constant. For the two sets mentioned above, it may be of interest to compare the maximum and minimum velocities. Those of the first set are +17 and +29 and of the second +19 and +23.5.

This solution must, however, owing to the peculiar behaviour of the star, be regarded as preliminary only. It is only when many more observations have been secured and the star has been closely followed for some time that any more definite idea of the nature of the changes taking place may possibly be obtained, and it is proposed in the future to follow it as closely as the other work on hand will permit.

I have the honour to be, sir,

Your obedient servant,

J. S. PLASKETT.

APPENDIX A.

ORBITS OF θ AQUILÆ, ϵ HERCULIS, AND η BOÖTIS.

W. E. HARPER.

THE ORBIT OF θ AQUILÆ.

The star θ Aquilæ ($\alpha = 20^h 06^m.2$, $\delta = -1^\circ 07'$, photographic magnitude 3.6) was discovered to be a spectroscopic binary by M. Deslandres* in 1902. From the twenty-six plates secured he obtained a period of 16.7 days and eccentricity about 0.6. As the results obtained by him were regarded as only provisional, the star was placed on our observing list here in May, 1907, when the single-prism spectrograph was ready for use. In all forty-five measurable plates were secured that year and from these, preliminary values of the elements were obtained.† For convenience of reference these are given here:

$$P = 17.17^d$$

$$\gamma = -26.7^{km}$$

$$e = 0.725$$

$$\omega = 20^\circ$$

$$T = 1907, \text{ Oct. 2.15 G.M.T.}$$

$$= \text{J. D. } 2,417,851.15$$

$$a \sin i = 8,455,500^{km}$$

As unfavourable weather prevented the securing of spectrograms in all its phases, particularly near the time of periastron passage, work was resumed on it this year with the object of filling up any gaps in the curve. Fifty-two spectrograms were secured this year and these have been combined with those of last year to determine the orbit. Some half-dozen plates of last year in which the agreement among the various lines was not all that could be desired were remeasured, but only two, Nos. 924 and 959, were changed in velocity appreciably. Plates 1038 and 1050 which had not been measured last year are also added.

Four of the plates (Nos. 1001, 1100, 1101 and 1794) were made with the three-prism spectrograph, whose linear dispersion at $H\gamma$ is 10.1 tenth-metres per millimetre. The balance were all made with the single-prism spectrograph which at $H\gamma$ has a linear dispersion of 30.2 tenth-metres per millimetre and gives the whole visible spectrum in sharp focus. The region used for velocity determinations is that lying between and including $H\beta$ and K . The plates used were Seed 27.

The spectrum is of the type VIIa, and in the portion used the Mg line (λ 4481) and K (λ 3933) are best defined. The hydrogen lines are fairly well measurable, especially $H\gamma$, the line λ 4549 is fairly sharp as are also the silicon lines. In addition to those given in Table I. some faint metallic lines also appear in some of the plates. The velocities corresponding to one revolution of the micrometer screw (0.5mm. pitch) are also attached.

* Bulletin Astronomique XX., 129, 1903.

† Journal of the Royal Astronomical Society of Canada I., 357, 1907.

TABLE I.
LINES IN θ AQUILE.

| Element. | Wave-Length. | Velocity per Revolution. |
|----------|--------------|--------------------------------|
| H. | 4861.527 | 1451 |
| Fe. | 4549.642 | 1204 |
| Mg. | 4481.400 | 1151 |
| H. | 4340.634 | 1044 |
| Fe. | 4233.328 | 964 |
| He. | 4143.928 | 898 |
| Si. | 4131.047 | 889 |
| Si. | 4128.211 | 887 |
| H. | 4101.890 | 868 |
| H. | 3970.177 | 774 |
| Ca. | 3933.825 | 749 |

Practically all the plates made have been used in the discussion, even although one or two have not been of the best quality, No. 863 being a case in point. In the preliminary curve for this year ($P=17.120$) No. 873 gave an abnormally high residual (-28km.) and following out a suggestion of Mr. J. S. Plaskett, to whom I am much indebted for help during this work, the result was omitted from consideration in the least-square solution, as an excessive residual tends to distort the elements out of all agreement with the mean values, as obtained from the remaining observations.

The following table gives all the data of the plates, the phase being reckoned from periastron, Julian Day 2,417,731.504, using the period finally determined, 17.112 days.

TABLE II.
MEASURES OF θ AQUILE.

| Plate No. | Julian Date. | Phase. | No. of lines. | Wt. | Velocity. | Residual. |
|-----------|---------------|--------|------------------|-----|-----------|-----------|
| | 1907. | | | | | |
| 803..... | 2,417,727.814 | 13.425 | 4 | 5 | 24 | 0.2 |
| 819..... | 737.787 | 6.284 | 4 | 5 | -39 | 3.1 |
| 841..... | 739.836 | 8.333 | 4 | 5 | -38 | 0.4 |
| 854..... | 741.813 | 10.310 | 4 | 5 | -42 | 5.9 |
| 865..... | 747.778 | 16.275 | 1 | 2 | +45 | 16.0 |
| 905..... | 759.777 | 11.162 | 5 | 4 | -40 | 5.2 |
| 924..... | 765.777 | 0.050 | 5 | 4 | -30 | 19.5 |
| 931..... | 766.711 | 0.984 | 7 | 5 | -30 | 9.8 |
| 942..... | 770.703 | 4.976 | 4 | 4 | -40 | 5.7 |
| 946..... | 773.713 | 7.986 | 3 | 3 | -43 | 5.0 |
| 959..... | 777.764 | 12.037 | 5 | 3 | -40 | 7.8 |
| 969..... | 784.760 | 1.921 | 4 | 4 | -40 | 1.8 |
| 1001..... | 798.660 | 15.821 | 5 | 4 | +19 | 6.2 |
| 1012..... | 801.692 | 1.741 | 4 | 3 | -39 | 2.0 |
| 1013..... | 803.573 | 3.622 | 6 | 4 | -51 | 4.1 |
| 1027..... | 815.630 | 15.679 | 3 | 3 | +10 | 1.1 |
| 1028..... | 815.669 | 15.718 | 2 | 5 | +11 | 1.0 |
| 1033..... | 825.612 | 8.549 | 4 | 3 | -38 | 0.6 |
| 1038..... | 831.635 | 14.572 | 4 | 2 | -8 | 3.6 |
| 1043..... | 833.673 | 16.610 | 7 | 3 | +55 | 10.5 |
| 1050..... | 837.614 | 3.438 | 4 | 4 | -47 | 0.4 |
| 1072..... | 849.543 | 15.367 | 5 | 4 | +3 | 1.3 |
| 1073..... | 849.559 | 15.383 | 4 | 5 | +1 | 2.1 |
| 1074..... | 849.589 | 15.413 | 6 | 5 | -7 | 9.4 |
| 1080..... | 850.502 | 15.326 | 3 | 2 | +28 | 2.6 |
| 1081..... | 850.521 | 16.345 | 5 | 3 | +33 | 0.8 |
| 1082..... | 850.548 | 16.372 | 6 | 4 | +30 | 3.8 |
| 1085..... | 850.613 | 16.437 | 8 | 5 | +25 | 10.5 |
| 1086..... | 850.642 | 16.466 | 5 | 3 | +36 | 1.0 |
| 1089..... | 851.328 | 0.240 | 5 | 4 | +18 | 12.0 |
| 1091..... | 851.570 | 0.282 | 3 | 2 | +28 | 0.2 |
| 1092..... | 851.589 | 0.301 | 5 | 2 | +23 | 2.6 |

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TABLE II.
MEASURES OF θ AQUILA.—Continued.

| Plate No. | Julian Date. | Phase. | No. of lines. | Wt. | Velocity. | Residual |
|-----------|---------------|--------|---------------|-----|-----------|-----------|
| 1907. | | | | | | |
| 1093. | 2,417,851.605 | 0 317 | 5 | 3 | + 26 | + 2.6 |
| 1094. | 851.625 | 0 337 | 2 | 1 | + 12 | + 9.0 |
| 1100. | 867.510 | 16 223 | 1 | 1 | + 28 | + 1.7 |
| 1101. | 867.574 | 16 287 | 3 | 3 | + 33 | + 4.0 |
| 1106. | 874.535 | 6 135 | 4 | 2 | - 44 | + 1.4 |
| 1128. | 884.437 | 16 038 | 5 | 5 | + 16 | - 4.0 |
| 1129. | 884.452 | 16 052 | 5 | 5 | + 32 | +11.6 |
| 1146. | 896.500 | 10 988 | 1 | 2 | - 35 | - 2.8 |
| 1149. | 898.448 | 12 936 | 3 | 1 | - 31 | - 3.4 |
| 1150. | 898.526 | 13 014 | 5 | 3 | - 20 | + 7.2 |
| 1154. | 899.445 | 13 933 | 4 | 3 | - 18 | + 1.8 |
| 1155. | 899.458 | 13 946 | 3 | 2 | - 30 | -10.0 |
| 1157. | 903.529 | 0 105 | 3 | 3 | - 33 | + 3.9 |
| 1908. | | | | | | |
| 1533. | 2,418,077.871 | 4 126 | 5 | 3 | 50 | - 3.0 |
| 1544. | 080.873 | 7 128 | 2 | 2 | - 37 | + 3.0 |
| 1576. | 096.857 | 6 000 | 3 | 3 | - 48 | - 5.0 |
| 1583. | 098.821 | 7 964 | 5 | 3 | - 31 | + 7.0 |
| 1604. | 105.814 | 14 943 | 7 | 3 | - 11 | - 5.0 |
| 1605. | 105.843 | 15 000 | 6 | 3 | - 15 | -10.0 |
| 1626. | 115.774 | 7 805 | 7 | 4 | - 29 | + 9.3 |
| 1634. | 117.824 | 9 855 | 7 | 5 | - 29 | + 7.5 |
| 1643. | 119.821 | 11 852 | 6 | 5 | - 30 | + 3.0 |
| 1651. | 120.781 | 12 812 | 9 | 5 | - 32 | - 4.0 |
| 1659. | 126.729 | 1 648 | 2 | 2 | - 36 | - 0.5 |
| 1679. | 131.785 | 6 704 | 5 | 3 | 39 | + 2.0 |
| 1691. | 133.812 | 8 731 | 5 | 3 | - 41 | - 4.0 |
| 1696. | 134.799 | 9 718 | 5 | 4 | - 34 | + 2.5 |
| 1704. | 136.818 | 11 737 | 6 | 2 | - 33 | \pm 0.0 |
| 1708. | 137.764 | 12 683 | 5 | 4 | - 26 | + 3.3 |
| 1716. | 138.809 | 13 728 | 7 | 5 | - 19 | + 2.5 |
| 1727. | 148.687 | 6 494 | 5 | 5 | - 37 | + 4.6 |
| 1730. | 149.735 | 7 512 | 5 | 4 | - 39 | \pm 0.0 |
| 1731. | 149.755 | 7 562 | 5 | 3 | - 41 | - 2.2 |
| 1732. | 150.760 | 8 567 | 5 | 3 | - 33 | + 4.3 |
| 1733. | 150.840 | 8 617 | 2 | 2 | - 41 | - 3.8 |
| 1735. | 151.743 | 9 551 | 6 | 3 | - 43 | - 6.5 |
| 1736. | 151.756 | 9 564 | 2 | 1 | 30 | + 6.5 |
| 1747. | 153.740 | 11 547 | 5 | 3 | 31 | + 3.0 |
| 1755. | 154.744 | 12 551 | 5 | 2 | - 31 | - 1.0 |
| 1756. | 154.764 | 12 571 | 5 | 3 | - 26 | + 4.0 |
| 1762. | 156.619 | 0 316 | 7 | 3 | - 35 | +10.0 |
| 1766. | 156.687 | 0 384 | 4 | 3 | - 33 | +13.0 |
| 1767. | 156.722 | 0 419 | 5 | 3 | - 16 | + 3.0 |
| 1769. | 156.784 | 0 481 | 3 | 2 | \pm 0 | - 8.0 |
| 1776. | 161.708 | 2 395 | 4 | 2 | - 41 | + 1.5 |
| 1777. | 161.740 | 2 443 | 7 | 4 | - 39 | + 4.0 |
| 1789. | 171.763 | 12 458 | 5 | 3 | - 21 | + 9.0 |
| 1794. | 173.697 | 14 392 | 5 | 3 | - 24 | 10.0 |
| 1799. | 174.635 | 15 328 | 8 | 2 | \pm 0 | - 1.0 |
| 1800. | 174.658 | 15 351 | 6 | 2 | - 2 | - 3.0 |
| 1801. | 174.695 | 15 398 | 6 | 3 | + 7 | + 4.5 |
| 1807. | 175.581 | 16 273 | 6 | 2 | + 29 | - 1.0 |
| 1808. | 175.605 | 16 297 | 7 | 2 | + 26 | 3.0 |
| 1810. | 175.645 | 16 337 | 5 | 2 | + 22 | -10.0 |
| 1811. | 176.645 | 0 228 | 5 | 3 | + 35 | + 4.0 |
| 1812. | 176.664 | 0 247 | 5 | 1 | + 39 | +10.0 |
| 1813. | 176.681 | 0 264 | 7 | 2 | - 35 | + 6.0 |
| 1814. | 177.659 | 1 242 | 6 | 4 | - 30 | - 1.5 |
| 1815. | 177.680 | 1 263 | 8 | 4 | - 33 | - 4.0 |
| 1822. | 178.702 | 2 285 | 7 | 5 | - 35 | + 7.0 |
| 1835. | 181.584 | 5 165 | 5 | 4 | - 49 | - 3.0 |
| 1864. | 188.678 | 12 259 | 8 | 5 | - 33 | - 1.7 |
| 1875. | 193.529 | 0 000 | 5 | 4 | + 51 | - 2.6 |
| 1876. | 193.570 | 0 040 | 5 | 4 | - 51 | + 1.0 |
| 1878. | 2,418,196.625 | 3 094 | 5 | 4 | - 48 | - 2.0 |

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The observations of 1907 and 1908 were grouped separately and the period which suited best was 17.120 days. The phases for this period were computed, being reckoned from an initial epoch T_0 , Julian Day 2,417,727, the date of the first observation. The observations of the two years were now combined and grouped into 18 normal places. Weights were assigned to these groups depending not only upon the sum of the weights of the individual plates, but upon the number of nights involved. The maximum weight was taken as 5. In the weighting of the individual plates, not only the quality of the plate *per se*, but the agreement among the various lines was taken into account. The groups are given in Table III.

TABLE III.
NORMAL PLACES.

| Mean Phase. | Mean Velocity. | Wt. | Mean Phase. | Mean Velocity. | Wt. |
|-------------|----------------|-----|-------------|----------------|-----|
| 1.09 | -22.3 | 3 | 5.49 | -31.3 | 2 |
| 2.13 | -11.7 | 1 | 6.47 | -38.2 | 3 |
| 2.66 | -0.7 | 3 | 7.96 | -48.9 | 2 |
| 3.09 | -13.3 | 1 | 9.46 | -44.5 | 1 |
| 3.42 | -24.9 | 2 | 10.73 | -40.5 | 2 |
| 3.72 | -34.3 | 3 | 12.05 | -36.4 | 2 |
| 4.31 | +51.0 | 1 | 13.93 | -37.4 | 5 |
| 4.54 | -33.6 | 1 | 16.28 | -33.0 | 2 |
| 4.72 | +22.5 | 3 | 17.05 | -26.7 | 3 |

Using the graphical method* of Dr. King, various values of e and ω were tried, those finally decided upon as suiting the grouped observations best being $e = .680$, $\omega = 20^\circ$, $K = 49\text{km.}$ and time of periastron passage, T , 4.30 days from initial epoch. Thus for preliminary elements we have:

$$P = 17.120 \text{ days}$$

$$e = 0.680$$

$$\omega = 20^\circ$$

$$T = \text{Julian Day } 2,417,731.30$$

$$K = 49\text{km.}$$

$$\gamma = -25.3\text{km.}$$

With these elements it was decided to make a least-square solution for the normal places. Using the differential equation of Lehmann-Filhés†

$$\delta \left(\frac{dz}{dt} \right) = \delta \gamma + (\cos u + e \cos \omega) \delta K + \left[\cos \omega - \frac{\sin u \sin v}{1 - e^2} \cdot (2 + e \cos v) \right] K \delta e \\ - [\sin u + e \sin \omega] \cdot K \delta \omega - \sin u (1 + e \cos v)^2 (t - T) \cdot \frac{K}{(1 - e^2)^{\frac{3}{2}}} \delta \mu \\ + \sin u (1 + e \cos v)^2 \frac{K}{(1 - e^2)^{\frac{3}{2}}} \mu \delta T$$

eighteen observation equations were formed, connecting the six unknowns with the residuals between the observed and computed values of the velocity. To make the observation equations homogeneous the following substitutions were made:—

$$x = \delta \gamma$$

$$y = \delta K$$

$$z = 10,000 \delta \mu$$

$$u = 100 \delta e$$

$$v = 10 \delta T$$

$$w = 10 \delta \omega$$

* Astrophysical Journal, XXVII., 125, 1908.

† Astronomische Nachrichten 3242.

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There result the following normal equations:—

$$\begin{aligned}
 40.000x + 9.571y - 15.914z - 11.075u + 5.696v + 4.981w + 18.200 &= 0 \\
 + 16.015y - 19.340z - 13.924u + 6.444v + 2.043w - 6.419 &= 0 \\
 + 242.697z + 11.554u - 327.008v + 255.472w + 14.267 &= 0 \\
 + 19.651u - 4.122v + 1.212w - 4.459 &= 0 \\
 + 486.538v - 372.234w - 36.352 &= 0 \\
 + 413.976w - 102.103 &= 0
 \end{aligned}$$

Whence the corrections to the first approximations:

$$\begin{aligned}
 \delta\gamma &= -0.6 \text{ km.} & \delta e &= + .011 \\
 \delta K &= +2.1 \text{ km.} & \delta T &= + 134 \text{ days.} \\
 \delta P &= - .004 \text{ days.} & \delta \omega &= 5^\circ.27
 \end{aligned}$$

The resulting elements with their probable errors, as determined at a later stage, are:

$$\left. \begin{aligned}
 P &= 17.116 \text{ days} & \pm .008 \text{ days.} \\
 e &= 0.691 & \pm .017 \\
 \omega &= 25^\circ.27 & \pm 2^\circ.1 \\
 T &= \text{J. D. } 2,417,731.434 & \pm .100 \text{ days.} \\
 K &= 51.1 \text{ km.} & \pm 3.20 \text{ km.} \\
 \gamma &= -25.9 \text{ km.} & \pm 0.64 \\
 A &= 83.0 \text{ km.} \\
 B &= 19.2 \text{ km.}
 \end{aligned} \right\} \text{Final elements (simple solution).}$$

The residuals from the curve using these corrected values of the elements seemed themselves to lie on a curve, which repeated itself approximately twice during the period of the principal star and having an amplitude of about 8 km. The way the residuals from the observed velocities grouped themselves was not mere chance, there was no doubt that there was some secondary disturbance. The assumption was therefore made that there was a third body whose period was commensurable with the period of the principal star, it going through all its phases in half the time required for that of the principal star. The orbit of the third body was considered circular and the secondary curve taken to cross the primary from above at a time T' , Julian Day 2,417,732.634. Taking K' as 4km. and considering θ as the angle at any time from T' the extra terms in the differential equation are:

$$- \sin \theta \delta K' + \frac{2\pi}{P'} \cdot K' \cdot \cos \theta \cdot \delta T'.$$

Correcting now our values of the computed velocity for each of the eighteen normal places by an amount representing that due to the third body we have a new set of eighteen observation equations connecting the eight unknowns. In these equations, for sake of homogeneity, we put

$$\begin{aligned}
 x &= \delta\gamma \\
 y &= \delta K \\
 z &= \frac{100 K}{(1 - e^2)^{\frac{3}{2}}} \cdot \delta u &= 13523.67 \delta p \\
 u &= K \cdot \delta e \\
 v &= \frac{K}{(1 - e^2)^{\frac{3}{2}}} \cdot \delta' \cdot \delta T &= 49.355 \delta T'. \\
 w &= K \cdot \delta \omega \\
 y' &= \delta K' \\
 v' &= \frac{2\pi}{P'} \cdot K' \cdot \delta T' &= 2.937 \delta T'.
 \end{aligned}$$

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There result the following normal equations:—

$$\begin{array}{rcl}
 40\cdot000x & + & 9\cdot394y - 16\cdot283z - 22\cdot704u + 3\cdot111v + 0\cdot405w + 7\cdot526y' + 3\cdot349v' + 33\cdot400 = 0 \\
 & + & 15\cdot353y - 19\cdot924z - 28\cdot003u + 3\cdot284v + 0\cdot016w + 11\cdot548y' + 2\cdot222v' - 50\cdot734 = 0 \\
 & + & 176\cdot184z - 20\cdot361u - 62\cdot767v + 43\cdot949w - 7\cdot554y' - 27\cdot991v' - 30\cdot492 = 0 \\
 & + & 82\cdot772u - 2\cdot485v + 0\cdot072w - 22\cdot165y' + 4\cdot273v' - 102\cdot683 = 0 \\
 & + & 24\cdot411v - 17\cdot105w - 0\cdot687y' + 9\cdot534v' - 3\cdot337 = 0 \\
 & + & 17\cdot037w + 2\cdot279y' - 10\cdot776v' + 9\cdot934 = 0 \\
 & + & 20\cdot463y' + 1\cdot950v' + 54\cdot446 = 0 \\
 & + & 19\cdot533v' - 1\cdot088 = 0
 \end{array}$$

Whence the following corrections are obtained:—

$$\begin{array}{ll}
 \delta\gamma = -0\cdot01 \text{ km.} & \delta T = +0\cdot00 \text{ days.} \\
 \delta K = -1\cdot4 \text{ km.} & \delta\omega = +0\cdot12 \\
 \delta P = -\cdot0017 \text{ days.} & \delta K' = -1\cdot3 \text{ km.} \\
 \delta e = +\cdot007 & \delta T' = +1\cdot59 \text{ days.}
 \end{array}$$

The resulting values of the elements with their probable errors, as determined at a later stage, are:

$$\left. \begin{array}{ll}
 P = 17\cdot114 \text{ days} & \pm \cdot008 \text{ days} \\
 e = 0\cdot698 & \pm \cdot017 \\
 \omega = 25^\circ\cdot39 & \pm 2^\circ\cdot45 \\
 T = \text{J. D. } 2,417,731\cdot464 & \pm \cdot092 \text{ days.} \\
 K = 49\cdot7 \text{ km.} & \pm 3\cdot31 \text{ km.} \\
 \gamma = -25\cdot91 \text{ km.} & \pm 0\cdot66 \text{ km.} \\
 T' = \text{J. D. } 2,417,732\cdot793 & \pm \cdot349 \text{ days.} \\
 K' = 2\cdot7 \text{ km.} & \pm 1\cdot02 \text{ km.} \\
 A = 81\cdot04 \text{ km.} & \\
 B = 18\cdot36 \text{ km.} &
 \end{array} \right\} \begin{array}{l} \text{First approximation (solution} \\ \text{(with secondary oscillation.))} \end{array}$$

The size of the corrections in some of the elements, and the fact that the residuals (computed—observed) as obtained direct were not in all cases in close agreement with those obtained from the differential equation, *i.e.*, by substituting the values of the corrections in the observation equations, made another solution necessary. The values of ω and γ were, however, considered established as the corrections were very small and the remaining six unknowns were, with the last elements as the basis, formed anew into eighteen observation equations. In these equations

$$\begin{array}{ll}
 y = \delta K. & \\
 z = \frac{100 K}{(1 - e^2)^{\frac{3}{2}}} \delta \mu & = 13534\cdot86 \delta \mu. \\
 u = K \cdot \delta e & \\
 v = \frac{K}{(1 - e^2)^{\frac{3}{2}}} \cdot \mu \cdot \delta T' & = 49\ 6906 \delta T'. \\
 y' = \delta K'. & \\
 v' = \frac{2 \pi}{P} \cdot K' \cdot \delta T' & = 1\cdot9825 \delta T'.
 \end{array}$$

There result the following normal equations:—

$$\begin{array}{rcl}
 14\cdot733y - 19\cdot889z - 28\cdot221u + 3\cdot499v + 11\cdot503y' + \cdot938v' + 1\cdot153 = 0 \\
 + 174\cdot454z + 23\cdot938u - 61\cdot517v - 10\cdot663y' - 26\cdot344v' + 17\cdot185 = 0 \\
 + 87\cdot120u - 4\cdot059v - 23\cdot403y' - 2\cdot458v' + 7\cdot668 = 0 \\
 + 23\cdot708v + \cdot794y' + 9\cdot359v' - 9\cdot616 = 0 \\
 + 21\cdot411y' + 1\cdot290v' + 1\cdot868 = 0 \\
 + 18\cdot584v' - 4\cdot992 = 0
 \end{array}$$

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Whence the corrections:

$$\begin{aligned}\delta K &= -0.02 \text{ km.} & \delta T &= +0.039 \text{ days.} \\ \delta P &= -0.0022 \text{ days.} & \delta K' &= -0.05 \text{ km.} \\ \delta e &= +0.0037 & \delta T' &= +0.080 \text{ days.}\end{aligned}$$

The corrected values of the elements with their probable errors, as determined at this stage, are:

| | | | |
|------------|---------------------|-----------------|---|
| $P =$ | 17.1121 days | $\pm .005$ days | } Second approximation (solution with secondary oscillation). |
| $e =$ | 0.6943 | $\pm .013$ | |
| $\omega =$ | $25^{\circ}.39$ | | |
| $T =$ | J. D. 2,417,731.503 | $\pm .070$ days | |
| $K =$ | 49.68 km. | ± 2.28 km. | |
| $\gamma =$ | -25.91 km. | | |
| $T' =$ | J. D. 2,417,732.873 | $\pm .416$ days | |
| $K' =$ | 2.65 km. | ± 0.86 km. | |
| $A =$ | 80.84 km. | | |
| $B =$ | 18.52 km. | | |

This solution should have been sufficient, but when substituting directly in the observation equations and comparing the residuals with those obtained in the ordinary way, there was one fairly large difference 0.40km., two were 0.30km. and the rest varied between 0.0 and 0.2 km. Furthermore, the probable errors of some of the quantities, particularly K , seemed too large. It was decided then to compute the probable errors corresponding to the previous corrections made. They are collected in the accompanying Table IV.:-

TABLE IV.

SUMMARY OF CORRECTIONS.

| Elements. | Preliminary Values. | First Corrected Values. | Second Corrected Values. | Third Corrected Values. |
|------------------|---------------------|---------------------------------|----------------------------------|--------------------------|
| P . . . | 17.120d | 17.116d $\pm .008$ | 17.114d $\pm .008$ | 17.112d $\pm .005$ |
| e . . . | 0.680 | 0.691 $\pm .017$ | 0.698 $\pm .017$ | 0.6943 $\pm .013$ |
| ω . . . | 20° | $25^{\circ}.27 \pm 2^{\circ}.1$ | $25^{\circ}.39 \pm 2^{\circ}.45$ | |
| T . . . | J. D. 2417731.30 | ...731.434 ± 100 | ...731.464 $\pm .092$ | ...731.503 $\pm .070$ |
| K | 49.0 km. | 51.1 km. ± 3.20 km. | 49.7 km. ± 3.31 km. | 49.68 km. ± 2.28 km. |
| γ | 25.3 km. | -25.9 km. ± 0.64 km. | -25.91 km. ± 0.66 km. | |
| | | Assumed. | | |
| T' | | (2417732.634) | ...732.793 $\pm .343$ | ...732.873 $\pm .416$ |
| K' | | (4.0 km.) | 2.7 km. ± 1.02 km. | 2.65 km. ± 0.86 km. |
| Σpr | 485 km. | 292 km. | 251 km. | 235 km. |

The values for P , γ , T' and K' were now considered determined. The probable errors, especially those in K , did not seem to be as low as they should be. As the probable error in ω in the later determination was larger than in the preceding one, it was thought advisable to take e , ω , T and K and see if by another solution lower probable errors would be had, and a better agreement between the ephemeris and equation.

As before, for the sake of homogeneity, let

$$\begin{aligned}x &= \delta K \\y &= K \delta e &= 49.68 \delta e \\z &= K \delta \omega &= 49.68 \delta \omega \\u &= \frac{K}{(1 - e^2)^{\frac{3}{2}}} \cdot \mu \delta T = 48.9307 \delta T.\end{aligned}$$

And the resulting normal equations are:

$$\begin{aligned}14.480x - 28.036y - .077z + 3.931u - 3.236 &= 0 \\85.688y + .387z - 3.660u + 4.604 &= 0 \\17.243z - 17.072u - 1.533 &= 0 \\24.149u + .080 &= 0\end{aligned}$$

from which corrections result as follows:—

$$\begin{aligned}\delta K &= + 0.29 \text{ km.} \\ \delta e &= + 0.0009 \\ \delta \omega &= + 0^{\circ}.1743 \\ \delta T &= + 0.0013 \text{ days}\end{aligned}$$

The final elements, taking into account the secondary oscillation, are then as follows. The Allegheny results as discussed later are, for purposes of comparison, given here:—

| OTTAWA. | | ALLEGHENY. | |
|----------------|---|--|---|
| $P =$ | $17.112 \pm .005.$ | $17.117 \pm .0042$ | } Final elements (solution with secondary oscillation.) |
| $e =$ | $0.695 \pm .010$ | $0.685 \pm .011$ | |
| $\omega =$ | $25^{\circ}.57 \pm 1^{\circ}.54$ | $17^{\circ}.53 \pm 1^{\circ}.58$ | |
| $T =$ | J. D. 2,417,731.504 $\pm .024$ | 1907, Aug. 28, .697 $\pm .034$ dys. | |
| $K =$ | $49.97 \text{ km.} \pm 1.35 \text{ km.}$ | $44.69 \text{ km.} \pm 1.15 \text{ km.}$ | |
| $\gamma =$ | $- 25.91 \text{ km.} \pm 0.66$ | $- 30.10 \text{ km.}$ | |
| $A =$ | 81.31 km. | 73.88 km. | |
| $B =$ | 18.63 km. | 15.50 km. | |
| $a \sin i =$ | $8,452,100 \text{ km.}$ | $7,665,000 \text{ km.}$ | |
| $P' =$ | 8.556 days | 8.558 days. | |
| $T' =$ | J.D. 2,417,732.873 $\pm .416$ | 1907, Sept. 9, .176 $\pm .368$ days | |
| $=$ | time when secondary crosses primary from above. | | |
| $K =$ | $2.65 \text{ km.} \pm 0.86$ | $2.39 \text{ km.} \pm 0.77 \text{ km.}$ | |
| $a' \sin i' =$ | $311,800 \text{ km.}$ | $281,000 \text{ km.}$ | |

What seems peculiar is that the least-square solution diminished the period in each case, although from a comparison of the 1907 and 1908 observations, when plotted the period would seem to be fixed about 17.120 days. The successive approximations in each case decreased the sum of the squares of the residuals, as seen from Table IV. The final approximation gave $\Sigma pvv = 238.3 \text{ km.}$, practically the same as the previous one. The agreement, however, between the equation and ephemeris is much improved, the greatest difference being 0.27 km.; the average 0.15 km. and the probable errors are much lower. Table V. contains the phases for the normal places, reckoned from periastron with the period finally adopted, 17.112 days; the corresponding velocity with its weight, and the residuals as computed directly.

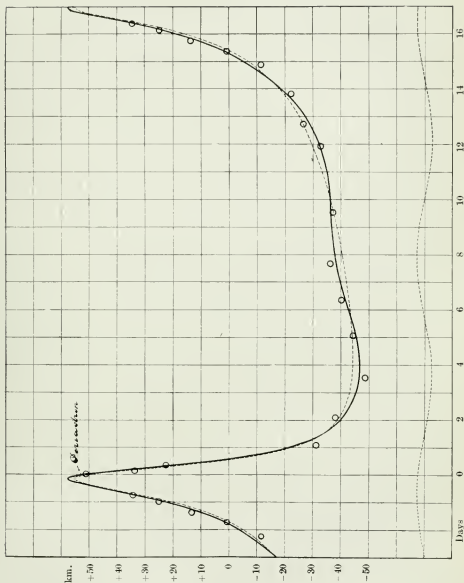


FIG. 17—Final Velocity Curve of θ Aquilae.

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TABLE V.
NORMAL PLACES.

| No. | Mean Phase from T | Mean Velocity. | Wt. | Residuals C - O |
|---------|------------------------|----------------|-----|--------------------|
| 1..... | 13.810 | -22.33 | 3 | +1.85 |
| 2..... | 14.871 | -11.75 | 1 | +4.21 |
| 3..... | 15.378 | +0.66 | 3 | +0.85 |
| 4..... | 15.740 | +13.33 | 1 | -3.21 |
| 5..... | 16.143 | +24.87 | 2 | -1.55 |
| 6..... | 16.385 | +34.34 | 3 | -0.44 |
| 7..... | 0.019 | +51.00 | 1 | +0.38 |
| 8..... | 0.166 | +33.60 | 1 | +4.75 |
| 9..... | 0.346 | +22.48 | 3 | -3.03 |
| 10..... | 1.102 | -31.31 | 2 | +5.95 |
| 11..... | 2.107 | -38.20 | 3 | -3.16 |
| 12..... | 3.533 | -48.93 | 2 | +1.93 |
| 13..... | 5.070 | -44.50 | 1 | -1.17 |
| 14..... | 6.357 | -40.50 | 2 | -1.53 |
| 15..... | 7.694 | -36.42 | 2 | -2.39 |
| 16..... | 9.527 | -37.38 | 5 | +0.36 |
| 17..... | 11.932 | -33.00 | 2 | +0.07 |
| 18..... | 12.713 | -26.74 | 3 | -2.31 |

The curve representing the final elements is shown in Fig. 17, the dotted lines being the velocity curves of the primary and secondary components and the heavy continuous line the resultant of these two. The final solution reduces the quantity Σprv of the residuals for the normal places from 485 to 238.3. The least-square solutions, with the assumption of a secondary disturbance, seem, therefore, to have materially improved the values of the elements. The probable error of a normal place of weight

unity as determined by $r = \pm .6745 \sqrt{\frac{\Sigma prv}{n - \mu}}$ where n is the number of normal places

and μ the number of unknowns is ± 2.75 km. The probable error of a plate as derived from the residuals in last column, Table II., which are scaled directly from the curve is for the 1907 observations ± 4.5 km., and for those of 1908 ± 3.5 km. Grouping the two years together the probable error of a plate is ± 4.0 km.

Previous Observations.

There remains a discussion of M. Deslandres' observations of 1901 and 1902. These were tried in connection with our 1907 observations to determine the period more accurately than could be done by using our own alone. The only period which suits Deslandres' observations alone is the one which he suggests, viz., 16.7 days. If the two observations of 1901 were omitted the other observations will give a better curve when a period of 17.112 days is used. Fig. 18 shows Deslandres' observations using his period of 16.7 days. Fig. 19 shows his 1902 observations using our period of 17.112 days. He suggested an eccentricity of about 0.6; such a value for e with $K = 45$ km. and $\omega = 27^\circ$, gives a curve represented by the broken line in Fig. 18, while a similar value for K and ω , with an eccentricity 0.4 is represented in the continuous curve and appears to suit the observations as well as, if not better, than the other. The velocities he gives as relative only; I have added 14 km. to each to bring them into agreement with the general run of mine.

As his measures depended upon one line only, $\lambda 4481$, and among themselves gave a more or less uncertain determination of the elements, I decided in my preliminary determination to confine myself to our own observations. Now that a definite solution has been secured, it is well to look at them anew. For convenience the data is repro-

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duced here, the tenth of a day being assumed. As stated before, 14km. is added to each velocity determination. The phase with the period 16.7 days is reckoned from the date of first observation of 1902, being Julian Day 2,417,964.4, the phase with the period 17.112 days is reckoned from my own periastron time.

M. DESLANDRES' OBSERVATIONS.

| Julian Date. | Phase $P = 16.7$ | Phase $P = 17.112$ | Velocity. |
|--------------|---------------------|-----------------------|-----------|
| 2,415,568.5 | 4.7 | 10.221 | + 11 |
| 583.5 | 3.0 | 8.109 | + 34 |
| 964.4 | 0.0 | 12.545 | - 2 |
| 969.4 | 5.0 | 0.433 | - 36 |
| 971.4 | 7.0 | 2.433 | - 46 |
| 982.4 | 1.3 | 13.433 | - 6 |
| 989.4 | 8.3 | 3.321 | - 40 |
| 2,416,010.4 | 12.6 | 7.209 | - 39 |
| 011.4 | 13.6 | 8.209 | - 36 |
| 012.4 | 14.6 | 9.209 | - 43 |
| 015.4 | 0.9 | 12.209 | - 25 |
| 020.4 | 5.9 | 0.097 | - 22 |
| 029.3 | 14.8 | 8.997 | - 31(?) |
| 040.3 | 9.1 | 2.885 | - 46(?) |
| 047.3 | 16.1 | 9.885 | - 24 |
| 048.3 | 0.4 | 10.885 | - 7 |
| 052.3 | 4.4 | 14.885 | + 39 |
| 054.3 | 6.4 | 16.885 | - 44 |
| 057.3 | 9.4 | 2.773 | - 48 |
| 069.3 | 4.7 | 14.773 | - 10 |
| 071.3 | 6.7 | 16.773 | - 26 |
| 072.3 | 7.7 | 0.661 | - 50 |
| 076.3 | 11.7 | 4.661 | - 47 |
| 086.3 | 5.0 | 14.661 | + 2 |
| 088.3 | 7.0 | 16.661 | - 15 |
| 2,416,005.3 | 14.0 | 6.549 | - 54 |

It is rather hard to say how best to make use of these early observations. Though the measures are liable to accidental errors of considerable magnitude they may, owing to the interval of some six years which has elapsed between the two series of observations, have an important bearing on whether or not any changes in the elements have taken place during that time. Our 1903 observations seemed to be slightly greater positive than the velocities for 1907 for the corresponding phase. This may have been accidental, the difference being at most less than 2 km. If the absolute velocities of Deslandres' observations were known, it would decide whether the velocity of the system has been changing or not during these six years.

If his two observations of the year 1901 are as they appear in his paper, we must conclude that the period has been changing during the interval. If we omit these two and use the remaining twenty-four of 1902 with our elements we get what appears on the face of it to be a much better agreement of the observations with the curve. There is one discrepancy. The observations fall short of the curve by a common amount, 1.5 days. The number of periods elapsed between the two epochs is in round numbers 125. By increasing the period $\frac{1.5}{125}$ or .012 days, this would be remedied, but while this value of 17.124 days would not make much difference in Deslandres' observations, the least-square solution in our own shows it to be improbable. Here is a suggestion: Is it not probable that the presence of the third body will cause a rotation of the line of apsides similar to that caused by the sun and moon on the earth? A motion of the apse line in the direction of ω decreasing and at the uniform rate of $\frac{.012}{17.112} \times 360^\circ$ or $0^\circ.2524$ per period would account for this discrepancy. This motion, if it exists,

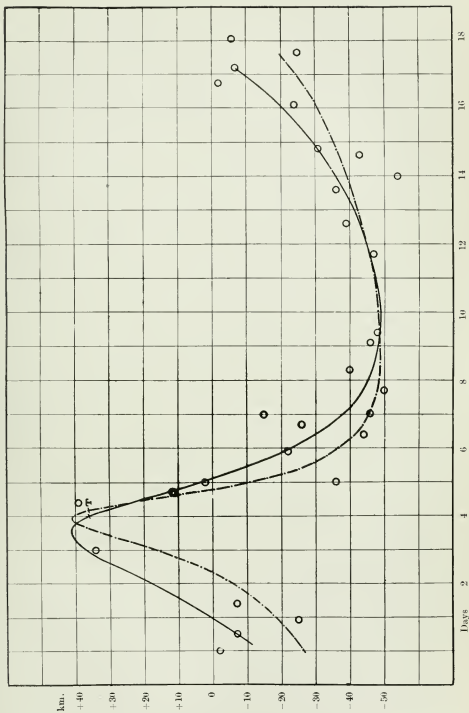


Fig. 18—M. Deslandres' Observations.



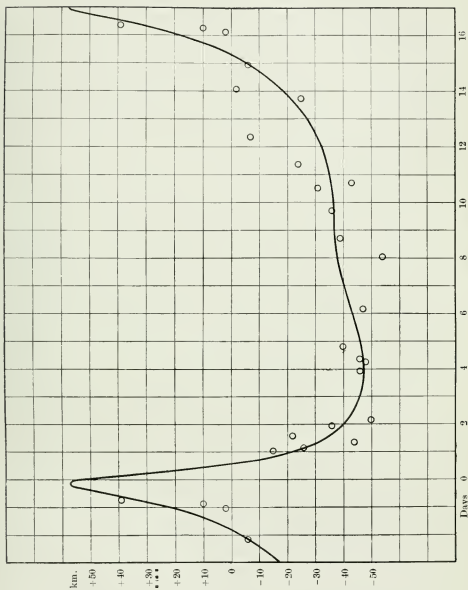


FIG. 19.—Deslandres' 1902 Observations.

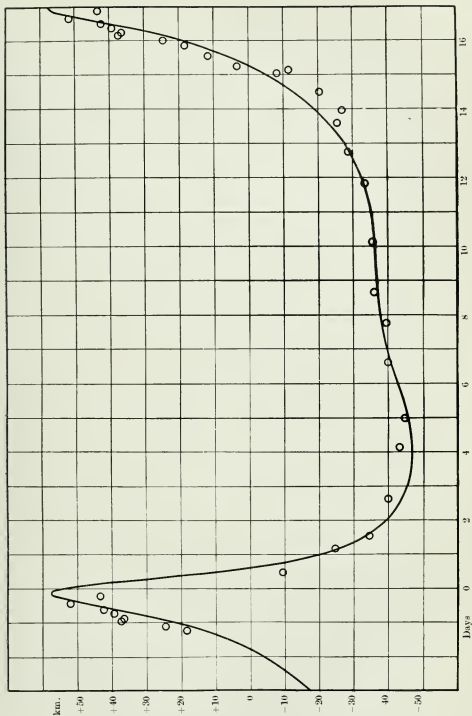


FIG. 20.—Alleged any Observations, Ottawa Curve.

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would, in addition to decreasing ω and consequently the slope of the curve near periastron, also cause the maximum positive velocity to increase and the maximum negative velocity to decrease numerically.

These questions seem to call for further work on the star at some future time. I do not think the data is sufficient at present to make any definite assertion regarding any change in the elements themselves.

Additional Note on the Allegheny Determination of the Orbit.

Since the foregoing was completed, No. 7 of Vol. I. of the Publications of the Allegheny Observatory has come to hand, containing the orbit of this same star as determined by Mr. Robert H. Baker. It is possibly the first case where two observers, working with different instruments and entirely independent of each other, have completed a discussion of an orbit at about the same time.

A comparison of the results is interesting. In some cases the agreement is remarkable, for instance the secondary oscillation; in other cases the agreement is not what might be expected. Speaking generally, I may say the reason for the differences exists in the observations themselves, the values Mr. Baker has determined suiting his observations best, while the same may be said of our own. There is a gap in the Allegheny observations near periastron passage. The first normal place, phase 0.16 days, depends upon two plates made the same night, the weights of the plates being about one-half the average weight assigned to a plate. The next normal place falls at phase 0.88 days and depends on two plates made on separate nights. These have relatively low weights also. In this interval of 0.7 days additional observations might, and I feel safe in saying, would tend to change the form of the curve. Our observations for phase 0.16 days depend upon one plate made in 1907 and three made in 1908, the plates being a little below the average weight. We have observations, however, for phase 0.34 days depending upon five plates made in 1907 and four made in 1908, the plates being all of average quality, and it is at this point that additional observations would be an advantage to the Allegheny data.

Looking at the results more in detail we see that Mr. Baker's value for γ is about 4km. more negative than ours. The greater positive velocities secured here, account in a measure for this. There may be an explanation also if the velocity of the system be changing, as suggested previously. The bulk of Allegheny observations were made in 1907, while ours are about equally distributed over 1907 and 1908. There is a minor cause in the assumed wave-lengths of the lines used, causing a systematic difference in the two series of velocities. The wave-lengths given in the first part of my report are those at present universally accepted: those given in Mr. Baker's work are sometimes greater, sometimes less, but on the whole would yield a velocity more negative than would those in use here.

The differences are indicated in the accompanying table:—

| Line. | Difference in Velocity. | Line. | Difference in Velocity. |
|---------------------|-------------------------|---------------------|-------------------------|
| λ 4549..... | 0.7 km. | λ 4131..... | - 1.2 km. |
| 4481..... | - 0.9 " | 4128..... | - 2.4 " |
| 4340..... | - 1.7 " | 3933..... | + 2.8 " |
| 4233..... | - 6.3 " | | |

On the average a difference of from 1 to 2 km. would be thus accounted for. In certain stars, by examining the trend of the residuals of the various lines and changing their assumed wave-lengths accordingly, a better agreement among the lines themselves can be secured, but unless there are valid reasons therefor it would seem better to retain a constant set of values. Mr. Baker no doubt has good reasons for the change, and the question of absolute velocity is not the most important one.

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The probable error of an average plate here is ± 4.0 , at Allegheny ± 3.3 . The Seed 23 plates used at Allegheny have an advantage over those used here as, being of a finer grain, the spectrum lines would be easier to measure. Our greater number of observations around periastron ought to have much weight, however, in the consideration of the differences between the two results.

The Allegheny observations, with a correction for T to bring the times of periastron passage into coincidence, and the addition of 3 km. to each velocity, being a systematic difference, are plotted in Fig. 20, the curve shown representing the elements as determined here. A glance suffices to show that such a curve does not suit the observations as well as their own curve, and it would seem, therefore, that some further work on the subject would be necessary to explain the discrepancies.

THE SYSTEM OF ϵ HERCULIS.

$$\alpha = 16^h 56^m.5, \delta = 31^\circ 4'.$$

This star was announced as a spectroscopic binary by both the Lick and Yerkes astronomers in 1903. The two plates secured at Lick showed both the Mg and $H\gamma$ lines as broad and diffuse. On the three plates secured at Yerkes, Adams noticed evidences of the composite nature of the spectrum.

Work was commenced on the star here May 24, 1907, and up to the present some one hundred spectrograms have been secured. After quite a number of these had been measured, the period was found to be in the neighborhood of four days. The observations seemed to group themselves into four sets, showing that the period was very close to the integral number. Thus quite an interval elapsed before observations were secured in the intermediate phases.

When in 1908 the curve was fairly complete an attempt was made to bring up the five early observations so as to determine the period with greater accuracy. The period which suited our 1907 and 1908 observations best was 4.012 days. The early observations, made about the same date in 1903, required an increase in the period of .0034 days. As the Lick observations were based on the Mg line alone and the Yerkes were for the brighter component and were regarded as provisional only, it was decided to confine our attention to our 1907 and 1908 plates alone.

Keeping the two years separate these were grouped into eighteen normal places. When an attempt was made by the graphical method of Dr. King to obtain preliminary values of the elements it was found that no simple elliptic curve would suit. Having previously found in θ Aquilæ that the assumption of a secondary disturbance due to the presence of a third body would account very well for deviations in the oscillation curve, a similar assumption was made in regard to this star. Here, however, the residuals from the most suitable elliptic curve seemed to repeat themselves thrice in the period of the main star. It was therefore assumed that there was this third body, if so we may speak of it, revolving about the bright star in a period one-third that of its primary, the two in turn revolving about the other component of the system. This was the theory first acted upon.

After a great many trials the set of elements which gave a resultant curve in best agreement with the observations were the following:—

$$P = 4.012 \text{ days}$$

$$e = .10$$

$$K = 56 \text{ km.}$$

$$\omega = 210^\circ$$

$$T = \text{J. D. } 2,417,721.512$$

$$\gamma = -28.15 \text{ km.}$$

$$K' = 12 \text{ km.}$$

$$T' = \text{J. D. } 2,417,722.162$$

= time where secondary crosses primary from above.

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With these elements a set of eighteen observation equations were formed connecting the eight unknown elements with the residuals. These were transformed into normal equations and the solution gave the following corrections to the elements accepted as preliminary. The new values are also given:—

| Elements. | Corrections. | Corrected Values. |
|----------------|---------------|-------------------|
| P | + .00065 days | 4.01265 days |
| e | + .030 | .070 |
| K | + .237 km. | 56.237 km. |
| ω | - 18' 35 | 191° 65 |
| T | - .178 days | J.D. 2417721.334 |
| γ | - 1.04 km. | - 29.19 km. |
| K' | + .262 km. | 12.262 km. |
| T' | + .015 days | J.D. 2417722.177 |

The new set of elements decidedly improved the agreement as is indicated by a decrease in the sum of the squares of the residuals from 1044 to 715, over thirty per cent. When, however, the residuals were computed directly and compared with those obtained by substitution in the observation equations the differences in most cases were larger than they should be, showing that another solution was necessary. Such a solution has as yet not been made.

Before the work had been carried thus far, observations had been made on the star in 1909. To bring these into agreement with the curve the period would need to be increased to 4.023 days; this period if used would utterly destroy the agreement of the first two years. It seemed then that the period was a varying quantity.

At this stage it was decided to review the plates for evidences of the spectrum of the other component. From time to time in measuring, notes had been made regarding any evidences of duplicity, with corresponding velocities, but now the plates were examined critically with this object in view. Out of the hundred odd plates only six showed the doubling of the lines. Two of them showed $H\gamma$ doubled, two $H\delta$ doubled and two both $H\delta$ and K . The instrument used in almost every case was the single-prism spectrograph which has a dispersion at $H\gamma$ of 30.2 tenth-metres per millimetre. At $H\delta$ the instrument should theoretically resolve lines differing in wave-length by 1.2 tenth-metres. This corresponds to a velocity of 90 km. per second. In practice, however, owing to various causes, a separation corresponding to a much greater difference in velocity would be necessary before the lines could be seen as doubled. The maximum separation found to exist is approximately 160 km. Hence, we can understand how such a small percentage of the plates showed the duplicity of the lines. In the case of these six plates the velocities corresponding to the two components are tabulated in the column of remarks, Table II.

In Vol. I., No. 13 of the Allegheny Publications, which came to hand while the plates were being reviewed, Mr. Robert H. Baker discussed the spectroscopic components of 2 Lacerte. His blended curve being very similar to that of ϵ Herculis, it seemed possible that the systems might be similar and that his explanation might answer in the case before us. The velocities, while very rough approximations at best, were plotted for each component and elements were obtained for the components as follows:—

| Elements. | Brighter component. | Fainter component. |
|--------------------|---------------------|--------------------|
| Maximum pos. vel | + 64 km. | + 40 km. |
| Maximum neg. " | - 138 " | - 96 " |
| K | 101 " | 68 " |
| e | .15 | .15 |
| ω | 216° | 30° |

Physical conditions in the system itself might serve to explain the curious form of the curve, but the two previous theories have much more evidence to support them. The change in the period, if real, would lend strength to the theory of a disturbing satellite. The presence of this third body would tend to cause the line of apsides to rotate, varying the form of the curve and consequently the elements.

Tables I. and II. give all the data of the plates. The residuals for each plate are scaled directly from the curve; the other columns are self-explanatory. Table III. gives the eighteen normal places, the phases being reckoned from the final periastron. The curve, Fig. 21, represents the corrected values of the elements on the assumption of a disturbing body; the dotted lines representing the primary and the secondary, and the heavy continuous one the resultant of the two.

Further work on the star is necessary. Spectrograms of the star at times of maximum velocities are now being secured on plates of fine grain, and it is hoped that some further evidences of the doubling of the lines will thus be secured.

TABLE I.

EARLY OBSERVATIONS OF ϵ HERCULIS.

| Julian Date. | Phase. | Velocity. | Residual. | Observatory. | Remarks. |
|---------------|--------|-----------|-----------|--------------|--------------------------|
| 2,416,235.687 | 3.046 | 58 | ..... | Yerkes. | ..... |
| 242.718 | 2.052 | - 43 | ..... | " | ..... |
| 259.910 | 3.193 | - 70 | ..... | Lick. | Mg. line. |
| 262.827 | 2.098 | - 34 | ..... | " | " |
| 272.664 | 3.910 | - 22 | ..... | Yerkes. | ..... |
| 616.680 | 2.837 | - 24* | ..... | Lick. | Mg. line, not very good. |
| 658.849 | .867 | - 31* | ..... | " | Mg. line. |

* Kindly communicated by Professor Campbell.

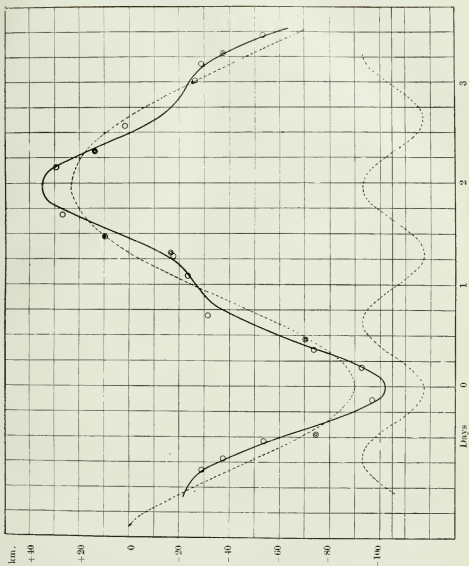


FIG. 21.—Velocity Curve of Hercules.



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TABLE 11.
OTTAWA MEASURES OF ϵ HERCULIS.

| No. of Plate. | Julian Date. | Phase. | Velocity | Wt. | Residual. | Remarks. |
|---------------|---------------|--------|----------|-----|-----------|---|
| 1907. | | | | | | |
| 786..... | 2,417,721.767 | 0.433 | -55.6 | 5 | +1.6 | |
| 801..... | 728.735 | 3.388 | -81.4 | 4 | -18.0 | |
| 810..... | 736.812 | 3.440 | -83.7 | 4 | +5.0 | |
| 816..... | 738.741 | 1.356 | +12.7 | 5 | +11.0 | |
| 827..... | 739.652 | 2.267 | -17.8 | 4 | +8.5 | |
| 838..... | 740.774 | 3.389 | -61.7 | 5 | +1.0 | H γ 128 and - 19 |
| 847..... | 741.767 | 0.370 | -83.2 | 5 | -24.0 | |
| 851..... | 742.738 | 1.341 | +7.0 | 6 | +6.0 | |
| 862..... | 748.692 | 3.282 | -34.5 | 5 | +15.0 | H γ 111 ₂ and - 15 ₁ |
| 871..... | 749.737 | 0.270 | -65.7 | 5 | +5.0 | |
| 881..... | 753.660 | 0.234 | -80.4 | 3 | -6.0 | |
| 893..... | 755.688 | 2.253 | +4.0 | 3 | -7.0 | |
| 913..... | 762.679 | 1.219 | -21.2 | 2 | -11.0 | |
| 920..... | 766.696 | 1.195 | -17.5 | 7 | -6.0 | |
| 928..... | 767.635 | 2.162 | +9.0 | 5 | -10.0 | Metallic lines seen. |
| 937..... | 768.622 | 3.149 | -39.0 | 4 | -2.0 | |
| 952..... | 776.673 | 3.175 | -57.6 | 4 | -18.0 | |
| 957..... | 778.693 | 1.182 | -7.0 | 7 | +6.0 | |
| 976..... | 790.722 | 1.173 | -26.8 | 5 | -12.8 | |
| 979..... | 792.562 | 3.013 | +15.4 | 6 | ..... | Mg - 125 ₁ and + 55 ₂ |
| 987..... | 795.732 | 2.170 | +6.2 | 3 | -12.0 | |
| 1018..... | 811.660 | 2.048 | -30.6 | 3 | +2.6 | |
| 1062..... | 2,417,840.609 | 2.908 | -2.9 | 2 | +22.0 | |
| 1908. | | | | | | |
| 1391..... | 2,418,010.868 | 0.623 | -28.6 | 6 | +8.0 | |
| 1403..... | 017.904 | 3.647 | -100.9 | 6 | -9.0 | H δ - 110 ₁ and + 28 ₁ |
| 1483..... | 045.900 | 3.555 | -90.7 | 3 | -8.2 | λ 4713 gives + 158 |
| 1494..... | 047.861 | 1.502 | +38.5 | 7 | +22.0 | |
| 1511..... | 054.856 | 0.472 | -37.0 | 7 | +12.4 | |
| 1531..... | 077.813 | 3.367 | -74.0 | 7 | -14.0 | |
| 1540..... | 080.767 | 2.307 | +6.1 | 6 | +1.0 | |
| 1545..... | 082.708 | 0.236 | -74.0 | 5 | +1.5 | |
| 1547..... | 084.770 | 2.298 | -28.5 | 2 | -34.5 | |
| 1567..... | 094.813 | 0.303 | -83.1 | 3 | -14.0 | |
| 1573..... | 096.747 | 2.237 | -11.0 | 6 | -23.5 | K intense to red. |
| 1582..... | 098.778 | 0.255 | -65.6 | 5 | +6.6 | |
| 1603..... | 105.774 | 3.239 | -46.2 | 4 | 0.0 | |
| 1625..... | 115.733 | 1.159 | -13.8 | 5 | +0.7 | |
| 1630..... | 117.691 | 3.117 | -31.0 | 8 | +3.5 | |
| 1640..... | 119.710 | 1.124 | +6.1 | 2 | +23.0 | Depends on Mg alone. |
| 1648..... | 120.715 | 2.129 | +24.8 | 6 | +3.4 | |
| 1653..... | 124.676 | 2.077 | +20.0 | 6 | -5.5 | |
| 1658..... | 126.680 | 0.069 | -99.5 | 3 | -7.0 | |
| 1661..... | 126.820 | 0.208 | -86.1 | 5 | -8.7 | |
| 1666..... | 129.730 | 3.119 | -27.0 | 7 | +8.0 | |
| 1675..... | 131.658 | 1.034 | -14.5 | 6 | +6.8 | |
| 1676..... | 131.688 | 1.064 | -22.2 | 6 | -2.2 | λ 4267 gives +128. |
| 1682..... | 132.716 | 2.092 | +31.2 | 6 | +6.2 | H δ - 80 and + 70 |
| 1685..... | 133.609 | 2.966 | -27.9 | 6 | 0.0 | K - 14 and + 62. |
| 1686..... | 133.649 | 3.026 | -36.0 | 5 | -6.6 | Metallic lines. |
| 1693..... | 134.707 | 0.071 | -108.0 | 5 | -16.0 | All lines def. on violet. |
| 1699..... | 136.679 | 2.042 | -26.0 | 4 | -2.6 | |
| 1707..... | 137.737 | 3.100 | -43.6 | 8 | -9.6 | |
| 1712..... | 138.708 | 0.059 | -81.1 | 5 | +8.1 | |
| 1713..... | 138.739 | 0.084 | -65.8 | 6 | +24.5 | |
| 1719..... | 139.725 | 1.075 | -13.8 | 6 | +6.0 | |
| 1720..... | 145.708 | 3.047 | -23.7 | 7 | -7.0 | |
| 1723..... | 147.583 | 0.908 | -23.8 | 9 | +2.2 | |
| 1728..... | 148.722 | 2.047 | -23.9 | 6 | +5.9 | |
| 1729..... | 149.707 | 3.033 | -17.6 | 8 | +12.2 | |
| 1734..... | 151.716 | 1.028 | -27.8 | 5 | -6.3 | |
| 1737..... | 152.508 | 1.911 | +34.3 | 8 | -0.5 | H δ - 84 and - 28 |
| 1738..... | 152.631 | 1.944 | +34.7 | 5 | +3.7 | K - 115 ₂ and 32 ₃ |
| 1743..... | 152.753 | 2.066 | +40.2 | 4 | +13.2 | |
| 1746..... | 153.712 | 3.026 | -22.3 | 3 | +7.0 | |
| 1751..... | 154.653 | 3.967 | -82.5 | 5 | +11.2 | |

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TABLE II.

OTTAWA MEASURES OF ϵ HERCULIS.—Continued.

| No. of Plate. | Julian Date. | Phase. | Velocity. | Wt. | Residual. | Remarks. |
|---------------|---------------|--------|-----------|-------|-----------|----------|
| 1908. | | | | | | |
| 1757..... | 2,418,154.795 | 0.096 | -94.3 | 5 | -4.8 | |
| 1760..... | 155.701 | 1.001 | -22.1 | 3 | +0.4 | |
| 1761..... | 159.586 | 0.873 | -28.6 | 8 | -2.2 | |
| 1774..... | 161.649 | 2.937 | -24.0 | 7 | +2.5 | |
| 1782..... | 169.701 | 2.964 | -35.0 | 7 | -8.7 | |
| 1793..... | 173.612 | 2.862 | -47.8 | 5 | -14.1 | |
| 1818..... | 178.585 | 3.843 | -92.4 | 7 | +4.2 | |
| 1838..... | 181.660 | 2.904 | -24.0 | 7 | 0.0 | |
| 1844..... | 182.588 | 3.811 | -98.9 | 8 | -2.8 | |
| 1853..... | 185.578 | 2.790 | -6.1 | 5 | +16.0 | |
| 1866..... | 189.604 | 2.804 | -20.1 | 4 | +2.0 | |
| 1903..... | 216.550 | 1.660 | +11.2 | 4 | -19.0 | |
| 1905..... | 217.516 | 2.627 | +21.0 | 5 | +37.8 | |
| 1906..... | 217.556 | 2.667 | +10.0 | 5 | +8.0 | |
| 1917..... | 220.531 | 1.628 | +18.1 | 2 | -9.1 | |
| 1926..... | 227.593 | 0.665 | -26.8 | 4 | +8.3 | |
| 1961..... | 259.440 | 0.411 | -70.3 | 4 | -14.2 | |
| 1983..... | 272.422 | 1.356 | -30.9 | 5 | -33.0 | |
| 1993..... | 278.461 | 3.382 | -30.0 | 5 | +29.0 | |
| 1909. | | | | | | |
| 2263..... | 2,418,346.923 | 3.629 | -43.5 | ..... | ..... |  |
| 2264..... | 346.958 | 3.664 | -30.3 | ..... | ..... |  |
| 2305..... | 360.899 | 1.554 | -18.3 | ..... | ..... |  |
| 2306..... | 360.942 | 1.597 | -16.4 | ..... | ..... |  |
| 2327..... | 369.883 | 2.512 | +49.5 | ..... | ..... |  |
| 2328..... | 369.935 | 2.564 | +12.5 | ..... | ..... |  |
| 2370..... | 379.788 | 0.379 | -78.0 | ..... | ..... |  |
| 2371..... | 379.808 | 0.399 | -54.3 | ..... | ..... |  |
| 2384..... | 381.814 | 2.405 | +36.4 | ..... | ..... |  |
| 2385..... | 381.833 | 2.424 | +38.4 | ..... | ..... |  |
| 2454..... | 397.836 | 2.376 | +30.0 | ..... | ..... |  |
| 2455..... | 397.861 | 2.401 | +29.8 | ..... | ..... |  |

TABLE III.

NORMAL PLACES.

| No. | Phase from T. | Mean Velocity. | Weight. | Residual O - C. |
|---------|---------------|----------------|---------|-----------------|
| 1..... | 0.337 | -70.22 | 2 | -6.72 |
| 2..... | 1.187 | -16.57 | 2 | -4.00 |
| 3..... | 1.348 | +9.59 | 1 | +8.65 |
| 4..... | 2.183 | +13.26 | 2 | -4.34 |
| 5..... | 3.168 | -37.65 | 2 | +0.46 |
| 6..... | 3.404 | -74.53 | 1 | -11.49 |
| 7..... | 0.571 | -31.63 | 1.5 | +9.40 |
| 8..... | 0.952 | -23.75 | 3.5 | +0.67 |
| 9..... | 1.152 | -17.80 | 3 | -2.87 |
| 10..... | 1.570 | -26.96 | 1 | +4.53 |
| 11..... | 2.034 | -29.16 | 5 | -0.23 |
| 12..... | 2.442 | +1.16 | 2 | +6.97 |
| 13..... | 2.889 | -26.60 | 4 | -2.61 |
| 14..... | 3.062 | -28.98 | 5.5 | +1.78 |
| 15..... | 3.340 | -53.30 | 1.5 | +2.20 |
| 16..... | 3.747 | -96.50 | 2.5 | +1.45 |
| 17..... | 0.048 | -92.52 | 2.5 | +1.26 |
| 18..... | 0.235 | -73.35 | 3 | +1.84 |

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THE SPECTROSCOPIC BINARY η BOÖTIS.

This star ($\alpha = 13^h 49^m.9$, $\delta = +18^\circ 54'$, photographic magnitude 3.8) was announced as a spectroscopic binary by Moore in L. O. B. 70, 1905. The thirteen measures given extended over the years 1897, 1899, 1901, 1903, 1904 and 1905. Of these, four were approximate, the remaining nine definite. Besides these measures there were available the recently published measures*, six in all, by Kustner of the Bonn Observatory.

Work was commenced on the star here June 25, 1906, and from that time until the date of the last plate mentioned, March 20, 1909, forty-five plates were secured. The determination of the orbit depends then on these sixty-four plates, thirteen of the Lick Observatory, six of the Bonn and the remaining forty-five of our own.

Some objection might be taken to the grouping of observations from different observatories in view of the possibility of a systematic difference in the results used, but it has been deemed expedient by the writer to use these early observations in conjunction with our own to make a preliminary determination of the orbit. Meanwhile plates of the star in the required phases will continue to be made with the new three-prism spectrograph, and when all phases are complete, which cannot be before January, 1910, a new determination of the elements will be made using our three-prism plates alone. The comparison of results ought to be worth the extra labour involved.

The star is of solar type, XIVa according to Miss Maury's grouping, and thus permits of accurate velocity determination. As a rule about fifteen lines were measured on each plate. The plates up to No. 752 were made with the Universal spectroscope, and were reduced by means of the Hartmann interpolation formula. From that time the plates were made with either the new single or the three-prism spectrograph, and were reduced from tables used here in which the micrometer settings for zero displacement of the lines are tabulated. Eleven were made with the former, twenty-one with the latter. The plates used were Seed 27. Our own plates made at the commencement of our work are weighted one-half; later plates with the Universal spectroscope, the single-prism plates, most of those made at Bonn, as well as those of 1897 and 1899 made at Lick, are weighted unity, while the later plates of Lick Observatory and our own new three-prism plates are weighted three.

The following tables contain all the data of the plates. The phases are reckoned from the period and periastron finally adopted and the residuals are scaled directly from the curve representing the final elements:—

OBSERVATIONS AT LICK OBSERVATORY.

| Julian Date. | Phase. | Velocity. | Weight. | Residual. |
|--------------|--------|-----------|---------|-----------|
| 2,413,959.8 | 192.9 | - 0.6 | 1 | - 0.4 |
| 4,035.7 | 268.8 | - 2. | 1 | + 2.3 |
| 4,036.7 | 269.8 | - 4. | 1 | + 0.3 |
| 4,057.6 | 290.8 | - 2. | 1 | + 3.4 |
| 4,693.8 | 431.6 | - 2.2 | 1 | + 3.4 |
| 5,524.6 | 271.7 | - 4.9 | 3 | - 0.4 |
| 6,259.6 | 16.1 | + 6.9 | 3 | - 0.1 |
| 6,542.6 | 299.1 | - 8.2 | 3 | - 2.4 |
| 6,571.6 | 328.1 | - 4.9 | 3 | + 1.9 |
| 6,603.6 | 360.1 | - 7.6 | 3 | - 0.1 |
| 6,646.6 | 403.1 | - 10. | 3 | - 2.8 |
| 6,658.6 | 415.1 | - 7.3 | 3 | - 0.6 |
| 6,850.9 | 112.1 | + 5.5 | 3 | + 0.1 |

* Astrophysical Journal, 27-5-1908.

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OBSERVATIONS AT BONN OBSERVATORY.

| Julian Date. | Phase. | Velocity. | Weight. | Residual. |
|--------------|--------|-----------|---------|-----------|
| 2,416,258.4 | 14.9 | + 7.6 | 3 | +0.7 |
| 6,595.5 | 352.0 | - 2.2 | 1 | +5.2 |
| 6,608.5 | 365.0 | - 4.2 | 1 | -3.3 |
| 6,994.4 | 255.6 | - 3.4 | 1 | +0.4 |
| 7,234.7 | 0.6 | + 6.2 | 1 | -1.5 |
| 7,369.4 | 138.3 | + 3.9 | 1 | -0.4 |

OTTAWA OBSERVATIONS.

| Plate Number. | Julian Date. | Phase. | Velocity. | Wt. | Residual. |
|---------------|--------------|--------|-----------|-----|-----------|
| 308 | 2,417,387.7 | 153.6 | - 0.2 | 0.5 | 2.5 |
| 313 | 389.6 | 155.5 | 0.0 | 0.5 | - 2.2 |
| 318 | 391.6 | 157.5 | 1.8 | 0.5 | - 0.3 |
| 320 | 396.6 | 162.5 | - 1.7 | 0.5 | - 3.4 |
| 333 | 398.6 | 164.5 | - 1.6 | 0.5 | - 3.2 |
| 366 | 429.6 | 195.5 | - 0.4 | 0.5 | 0.0 |
| 372 | 431.6 | 197.5 | - 4.7 | 0.5 | - 4.2 |
| 657 | 643.8 | 409.7 | - 5.6 | 1.0 | - 1.3 |
| 670 | 655.8 | 421.7 | - 6.9 | 1.0 | - 0.6 |
| 691 | 669.7 | 435.6 | -10.2 | 1.0 | - 5.0 |
| 731 | 685.8 | 451.7 | - 3.8 | 1.0 | - 0.5 |
| 739 | 692.7 | 458.6 | - 4.5 | 1.0 | - 2.3 |
| 752 | 703.6 | 469.5 | + 0.7 | 1.0 | - 0.9 |
| 760 | 710.7 | 476.6 | - 0.1 | 3.0 | - 1.2 |
| 764 | 716.7 | 482.6 | + 2.9 | 3.0 | + 0.7 |
| 769-771 | 718.7 | 484.6 | + 2.5 | 2.0 | - 0.2 |
| 774 | 719.6 | 485.5 | + 3.2 | 1.0 | + 0.4 |
| 779 | 720.6 | 486.5 | + 0.6 | 1.0 | - 2.4 |
| 793 | 725.7 | 491.6 | + 5.7 | 1.0 | - 1.7 |
| 797 | 727.6 | 493.5 | + 5.1 | 1.0 | - 0.8 |
| 812 | 737.6 | 8.1 | + 7.2 | 1.0 | + 1.4 |
| 868 | 748.6 | 19.1 | + 5.0 | 1.0 | - 2.4 |
| 891 | 754.6 | 25.1 | + 5.7 | 1.0 | - 2.3 |
| 918 | 765.6 | 36.1 | + 6.8 | 1.0 | - 1.8 |
| 950 | 775.6 | 46.1 | + 5.3 | 1.0 | - 3.5 |
| 972 | 789.6 | 60.1 | +11.4 | 1.0 | - 2.8 |
| 990 | 795.6 | 66.1 | + 9.0 | 3.0 | 0.6 |
| 1231 | 955.9 | 226.4 | - 3.3 | 1.0 | - 1.1 |
| 1294 | 968.8 | 239.3 | - 3.8 | 3.0 | - 0.9 |
| 1307 | 970.9 | 241.4 | - 3.5 | 3.0 | - 0.4 |
| 1332 | 989.9 | 269.4 | - 5.2 | 3.0 | - 1.2 |
| 1357 | 996.8 | 267.3 | - 7.1 | 3.0 | - 2.7 |
| 1446 | 2,418,031.9 | 302.4 | - 7.5 | 3.0 | - 1.6 |
| 1513 | 066.8 | 337.3 | - 6.7 | 3.0 | - 0.3 |
| 1557 | 085.7 | 356.2 | - 8.7 | 3.0 | - 1.3 |
| 1553 | 087.7 | 358.2 | - 6.6 | 3.0 | - 0.8 |
| 1621 | 115.6 | 386.1 | - 6.0 | 3.0 | - 1.0 |
| 1663 | 129.6 | 400.1 | - 7.4 | 3.0 | - 0.1 |
| 1710 | 138.6 | 409.1 | - 6.8 | 3.0 | - 0.2 |
| 1792 | 173.5 | 444.0 | 8.6 | 3.0 | 4.3 |
| 1867 | 192.5 | 463.0 | - 0.3 | 3.0 | - 1.2 |
| 2115 | 315.0 | 90.2 | + 8.6 | 3.0 | - 1.7 |
| 2209 | 337.8 | 113.0 | - 5.2 | 3.0 | - 0.2 |
| 2283 | 355.8 | 131.0 | + 6.0 | 3.0 | + 2.1 |
| 2306 | 386.7 | 161.9 | + 2.8 | 3.0 | + 1.0 |

The observations when plotted gave a period about 492 days. Using this period they are combined into twenty-one groups, no group including observations of different periods. Preliminary elements were determined by the graphical method* of Dr.

* A. J., 27-2-1908.

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King and, using these, twenty-one observation equations of the form of Lehmann-Filhés were formed. They were then transformed into the following normal equations, where for sake of homogeneity these substitutions were made:

$$\begin{aligned}x &= \delta\gamma \\y &= \delta K \\z &= K \cdot \delta e \\u &= K \cdot \delta \omega \\v &= 1000 \cdot \frac{K}{(1 - e^2)^{\frac{3}{2}}} \cdot \delta \mu \\w &= \mu \cdot \frac{K}{(1 - e^2)^{\frac{3}{2}}} \cdot \delta T.\end{aligned}$$

The normal equations are:—

$$\begin{aligned}116\ 000x - 11\ 974y + 1\ 830z + 19\ 935u - 2\ 354v - 20\ 565w + 6\ 260 &= 0 \\54\ 535y - 14\ 444z + 2\ 376u - 13\ 460v - 7\ 212w - 28\ 055 &= 0 \\57\ 796z - 2\ 404u - 4\ 352v + 3\ 883w - 19\ 760 &= 0 \\59\ 931u - 13\ 104v - 62\ 528w - 4\ 652 &= 0 \\45\ 343v + 14\ 515w + 40\ 046 &= 0 \\69\ 129w + 7\ 200 &= 0\end{aligned}$$

The solution of these equations gave as corrections:

$$\begin{aligned}\delta\gamma &= -\ .02\ \text{km.} \\ \delta K &= +\ .43\ \text{"} \\ \delta e &= +\ .050 \\ \delta \omega &= -\ 1^{\circ}.025 \\ \delta P &= +\ 3.32\ \text{days} \\ \delta T &= -\ .520\ \text{"}\end{aligned}$$

The sum of the squares of the residuals for the normal places was reduced from 186.1 to 122.7, and the agreement between equation and ephemeris residuals was considered satisfactory. These are given in the accompanying table of normal places:

NORMAL PLACES.

| No. | Mean Phase. | Mean Vel. | Wt. | Residual. | Equation-Ephemeris. |
|-----|-------------|-----------|-----|-----------|---------------------|
| 1. | 255.5 | -2.15 | 4 | +1.64 | -0.13 |
| 2. | 431.6 | -2.20 | 1 | +3.41 | -0.08 |
| 3. | 271.7 | -4.90 | 1 | -0.33 | -0.26 |
| 4. | 15.5 | +7.25 | 6 | +0.28 | -0.08 |
| 5. | 333.0 | -6.90 | 16 | +0.02 | -0.56 |
| 6. | 112.1 | +5.50 | 3 | +0.11 | -0.14 |
| 7. | 255.6 | -3.40 | 1 | +0.39 | -0.03 |
| 8. | 0.6 | +6.20 | 1 | +1.50 | -0.13 |
| 9. | 138.3 | +3.90 | 1 | +0.45 | -0.29 |
| 10. | 435.5 | 6.20 | 5 | -0.96 | +0.01 |
| 11. | 417.7 | -7.60 | 9 | -0.98 | -0.01 |
| 12. | 480.8 | +1.63 | 11 | -0.21 | -0.03 |
| 13. | 463.0 | -0.30 | 3 | +1.19 | -0.12 |
| 14. | 0.9 | +6.00 | 3 | +1.25 | -0.04 |
| 15. | 48.1 | +7.65 | 8 | -1.17 | +0.02 |
| 16. | 111.4 | +6.60 | 9 | +1.16 | -0.02 |
| 17. | 161.9 | +2.80 | 3 | +1.02 | 0.00 |
| 18. | 169.5 | -0.97 | 3 | -2.23 | 0.00 |
| 19. | 238.4 | -3.60 | 7 | -0.70 | -0.32 |
| 20. | 276.7 | 6.60 | 9 | -1.81 | -0.02 |
| 21. | 359.4 | 7.00 | 12 | -0.49 | -0.06 |

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The probable error of a plate as determined from the last two columns of the table, giving the data of the plates and using the formula $r = \pm .6745 \sqrt{\frac{\sum pvv}{\sum p - 1}}$ is ± 1.04 km. per second. The curve, Fig. 22, is plotted from the corrected elements given in the following table. These are considered close approximations to the true values until observations in all phases of the star have been secured with the three-prism spectrograph when a final determination will be made:—

ELEMENTS OF ORBIT.

| Elements. | Graphical. | Corrected. |
|---|-----------------|------------------|
| Period P | 492 days. | 495.3 days. |
| Eccentricity e | 0.25 | 0.300 |
| Longitude of apse ω | 300° | 298° 98 |
| Half amplitude K | 7.8 km. | 8.23 km. |
| Velocity of system γ | -0.57 km. | -0.60 km. |
| Periastron passage T | J. D. 2417730.0 | J. D. 2417729.48 |
| Projection semi-major axis $a \sin i$ | | 53,474,000 km. |
| prr | 186.1 | 122.7 |

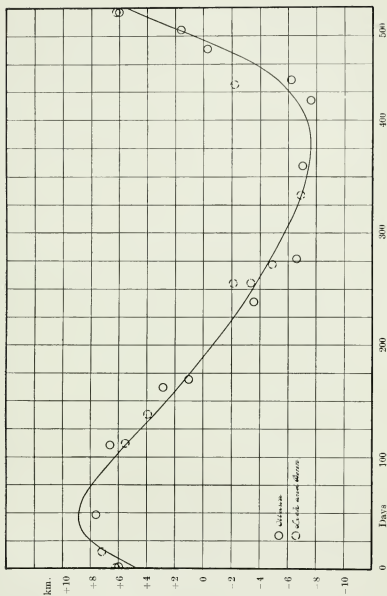


FIG. 22.—Velocity Curve of η Boötis.

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APPENDIX B.

THE SPECTROSCOPIC BINARY, α CORONÆ BOREALIS.

J. B. CANNON.

The star α Coronæ Borealis ($\alpha = 15^h 30^m$; $\delta = +27^\circ 3'$), was discovered to be a binary by Hartmann from measures of six plates taken at Potsdam in 1902 and 1903.* It was under observation at this Observatory during the years 1907 and 1908. In all 103 plates were secured, 46 in 1907 and the remaining 57 in 1908; the instrument used being the single-prism spectroscope.

This star belongs to the class Ia 2 in the Vogel classification. The spectrum shows the dark lines, $H\beta$, $H\gamma$, $H\delta$, $H\epsilon$, the magnesium line $\lambda 4481$, the iron line $\lambda 4549$, the calcium line $\lambda 3934$ and a few other very faint lines. The hydrogen lines are all very broad and diffuse and very difficult of accurate measurement. $H\epsilon$ is so diffuse that it has not been measured at all. The line $\lambda 4481$ varies in character, in some plates well defined, in others diffuse. The line $\lambda 4549$ is very faint and has only been measured in a very few cases. The line $\lambda 3934$ is in general a fairly good line, being weighted about the same as $H\gamma$ and $H\delta$. In the measurement of nearly every plate it was found that the lines $\lambda 4481$ and $\lambda 4549$ gave entirely different velocities from the H lines and K . It was decided therefore to consider only $H\beta$, $H\gamma$, $H\delta$ and K in the first measurements and the elements determined in this treatment are from the consideration of these alone.

The lines measured, together with the velocities per revolution of the micrometer screw (0.5 pitch), are given in Table I.

TABLE I.
LINES (MEASURED) IN α CORONÆ BOREALIS.

| Element. | Wave-Length. | Velocity per revolution. |
|---------------|--------------|--------------------------|
| Hydrogen..... | 4861.527 | 1451 |
| " | 4340.634 | 1044 |
| " | 4101.890 | 868 |
| cium | 3933.825 | 749 |

These lines vary in quality and were weighted accordingly. The whole plate was then weighted, regard being had, first, to the appearance of the spectrum, and second and more particularly, to the number of lines measured and the agreement in the measurements. The velocities found were plotted successively and gave a period of between seventeen and eighteen days. Trials of several periods ranging between these, gave 17.35 as the most satisfactory. There were available measurements of three plates of 1902 and ten of 1903 taken at Potsdam*, and it was found that on plotting these with the observations obtained here that if the period were increased to 17.355 days, they would, with one exception, lie very close to the curve. Table II. contains

* A. N., 163, 31, 1903.

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the number of the plate, the Julian date, the phase—computed from the time of periastron finally accepted, and period 17.355 days,—the weight of the plate, the velocity and the residual between the observed velocity and that computed from the corrected elements.

In order to obtain observations in which the errors might be reduced and a curve drawn showing smaller residuals, the one hundred and three observations were combined into fourteen groups. Plates of both years were combined indiscriminately, those at nearly the same phase being grouped together. The weight of each plate (Table II.) was taken into account and the weighted mean of each group computed, with the mean phase.

(Table III. contains the mean phase from T mean velocity, weight and residual of these normal places.)

TABLE II.
MEASURES OF α CORONÆ BOREALIS.

| Plate No. | Year. | Julian Day. | Phase. | Wt. | Velocity. | Residual. |
|---------------|-------|--------------|--------|-----|-----------|-----------|
| 784 | 1907. | 2,417.720.74 | 13.041 | 4 | -40 | +12.5 |
| 790 | " | 725.63 | 0.576 | 4 | +32 | 0. |
| 794 | " | 725.75 | 0.696 | 3 | +44 | -10. |
| 800 | " | 727.72 | 2.666 | 3 | -17 | +17. |
| 808 | " | 735.69 | 10.636 | 3 | -37 | +15. |
| 813 | " | 737.64 | 12.581 | 4 | -30 | +3. |
| 830 | " | 738.74 | 13.681 | 2 | -26 | 0. |
| 837 | " | 739.73 | 14.671 | 4 | -17 | -3.5 |
| 845 | " | 740.69 | 15.641 | 3 | -1 | -8. |
| 950 | " | 741.69 | 16.641 | 4 | +11 | -1.5 |
| 861 | " | 747.67 | 5.266 | 2 | +17 | -4.5 |
| 869 | " | 748.64 | 6.236 | 4 | +9 | -4.5 |
| 880 | " | 752.65 | 10.246 | 1 | -41 | +20. |
| 888 | " | 753.62 | 11.216 | 2 | -27 | -3. |
| 892 | " | 754.64 | 12.236 | 4 | -28 | -1. |
| 912 | " | 761.64 | 1.876 | 2 | +25 | -13.5 |
| 917 | " | 762.64 | 2.876 | 3 | +30 | -2.5 |
| 919 | " | 765.65 | 5.886 | 3 | +8 | 0. |
| 927 | " | 766.61 | 6.846 | 3 | -5 | -4.5 |
| 936 | " | 767.58 | 7.816 | 4 | +8 | -15. |
| 939 | " | 769.68 | 9.916 | 3 | -29 | -10. |
| 941 | " | 770.64 | 10.876 | 1 | -30 | -7. |
| 944 | " | 773.62 | 13.851 | 2 | -26 | -0.5 |
| 951 | " | 775.62 | 15.851 | 3 | -19 | -15. |
| 956 | " | 777.67 | 0.546 | 3 | -32 | 0. |
| 973 | " | 789.58 | 11.466 | 2 | -16 | -9. |
| 978 | " | 791.54 | 14.421 | 3 | -24 | +1.5 |
| 986 | " | 794.69 | 0.216 | 2 | -12 | -16. |
| 1060 and 1061 | " | 839.77 | 10.386 | 2 | -25 | +4. |
| 1006 | " | 800.69 | 6.216 | 2 | -14 | -18. |
| 1014 | " | 803.63 | 9.156 | 2 | -7 | -8.5 |
| 1017 | " | 810.63 | 16.161 | 1 | -14 | -13. |
| 1022 | " | 811.66 | 17.151 | 1 | +5 | -15. |
| 1026 | " | 815.50 | 3.676 | 3 | -30 | -4. |
| 1032 | " | 825.57 | 13.741 | 2 | -22 | -3.5 |
| 1037 | " | 831.67 | 2.486 | 2 | +36 | -0.5 |
| 1047 and 1048 | " | 837.53 | 8.356 | 3 | -15 | +5. |
| 1083 and 1084 | " | 850.56 | 4.016 | 4 | -26 | -2.5 |
| 1303 | 1908. | 2,418.010.92 | 8.186 | 3 | -5 | -0.5 |
| 1402 | " | 017.87 | 15.136 | 3 | -17 | -1. |
| 1493 | " | 047.80 | 10.356 | 3 | -6 | -15. |
| 1571 and 1572 | " | 096.69 | 7.181 | 3 | -15 | -12.5 |
| 1581 | " | 098.73 | 9.221 | 1 | -5 | -10. |
| 1601 | " | 105.71 | 16.201 | 3 | +7 | +5.5 |
| 1608 | " | 110.58 | 3.716 | 3 | +9 | +17. |
| 1623 and 1624 | " | 115.69 | 8.831 | 4 | -14 | +1. |
| 1628 and 1629 | " | 117.64 | 10.776 | 3 | -11 | -11.5 |
| 1638 and 1639 | " | 119.66 | 12.796 | 4 | -21 | -6.5 |
| 1646 and 1647 | " | 120.68 | 13.816 | 3 | -21 | -4.5 |
| 1652 | " | 124.64 | 0.421 | 3 | +42 | -11. |
| 1656 and 1657 | " | 125.64 | 2.421 | 3 | +27 | -10. |
| 1655 | " | 129.70 | 5.481 | 3 | +12 | -1. |

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TABLE II.
MEASURES OF α CORONÆ BOREALIS—Continued.

| Plate No. | Year. | Julian Day. | Phase. | Wt. | Velocity. | Residual. |
|----------------------------|-------|--------------|--------|-----|-----------|-----------|
| 1673 and 1674 | 1908. | 2,418,131.62 | 7.401 | 4 | - 3 | - 1.5 |
| 1683 and 1684 | " | 133.57 | 9.351 | 3 | 18 | + 2' |
| 1692 | " | 134.68 | 10.461 | 2 | 29 | + 7.5 |
| 1697 and 1698 | " | 136.65 | 12.431 | 4 | - 24 | - 3 |
| 1711 | " | 138.68 | 14.461 | 4 | 17 | + 5' |
| 1721 and 1722 | " | 147.54 | 5.966 | 6 | 0 | + 7' |
| 1739 | " | 152.65 | 11.076 | 2 | - 44 | - 20' |
| 1748 and 1749 | " | 154.57 | 12.906 | 6 | - 36 | + 8.5 |
| 1764 | " | 159.64 | 0.711 | 4 | + 37 | - 3' |
| 1773 and 1775 | " | 161.60 | 2.671 | 7 | + 43 | - 8.5 |
| 1798 | " | 174.54 | 15.611 | 2 | - 16 | - 6' |
| 1809 | " | 175.62 | 16.681 | 3 | - 3 | + 13' |
| 1816 and 1817 | " | 178.55 | 2.266 | 6 | + 41 | - 4' |
| 1827 | " | 179.54 | 3.256 | 2 | + 27 | - 2.5 |
| 1836 | " | 181.61 | 5.326 | 4 | + 10 | - 2' |
| 1841 and 1842 | " | 182.54 | 6.256 | 7 | + 8 | - 3.5 |
| 1852 | " | 185.56 | 9.276 | 2 | - 15 | - 0.5 |
| 1861 | " | 188.53 | 12.246 | 4 | - 30 | + 3.5 |
| 1865 | " | 189.56 | 13.276 | 1 | - 15 | - 12' |
| 1882 and 1883 | " | 199.54 | 5.901 | 8 | + 11 | - 3.5 |
| 1894, '95, '96 and '97 . . | " | 204.50 | 10.861 | 10 | - 21 | - 2' |
| 1949, 1950 and 1951 . . | " | 247.45 | 1.746 | 6 | + 46 | - 7.5 |
| 1991 | " | 278.42 | 15.261 | 1 | + 8 | - 20' |

TABLE III.

NORMAL PLACES OF α CORONÆ BOREALIS.

| No. | Mean Phase. | Mean Velocity. | Wt. | Residual. |
|--------------|-------------|----------------|-----|-----------|
| 1 | 12.656 | - 29.77 | 6 | - 2.37 |
| 2 | 13.777 | - 23.54 | 2 | - 2.34 |
| 3 | 14.664 | - 18.50 | 3 | - 2.29 |
| 4 | 15.831 | - 5.77 | 2.5 | - 0.36 |
| 5 | 16.723 | + 5.00 | 1.5 | - 6.22 |
| 6 | 0.556 | + 34.63 | 4 | - 2.17 |
| 7 | 2.302 | + 37.14 | 6 | - 0.71 |
| 8 | 3.559 | + 24.33 | 3 | - 2.66 |
| 9 | 5.657 | + 11.10 | 4 | - 2.47 |
| 10 | 6.250 | - 2.41 | 4 | - 1.46 |
| 11 | 7.968 | - 6.71 | 4 | - 1.65 |
| 12 | 9.444 | - 17.27 | 2 | - 0.31 |
| 13 | 10.517 | - 22.21 | 3 | - 0.25 |
| 14 | 11.090 | - 24.35 | 3 | + 0.75 |

From the radial velocity curve the elements of the orbit were determined by the graphic method of Dr. King.* These were:—

$$P = 17.355 \text{ days}$$

$$T = \text{J. D. } 2,417,725.55$$

$$K = 33 \text{ km.}$$

$$e = .28$$

$$\omega = 309^\circ$$

$$\gamma = 0 \text{ km.}$$

* Astro. Journal, Vol. XXVII.

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To obtain elements which would give a curve more nearly suiting the normal places, a least-square solution was made. On the advice of Mr. Plaskett, the period 17.355 days was taken as fixed, and the fourteen observation equations (formed by the method of Lehmann-Filhés²⁵) were determined without considering $\delta\mu$. From these the following normal equations result:—

$$\begin{array}{rcl} -48x & 0'4500y & +3'7267z + 1'1799u + 2'8166v - 14'1350 - n = 0 \\ +24'0451y & -7'2422z & + '4420u - '1050v - 4'1083 - n = 0 \\ & +23'0108z & - '2779u - '8737v + 3'9440 - n = 0 \\ & & +19'5267u + 17'5676v + 63'4280 - n = 0 \\ & & +17'8291v + 67'9099 - n = 0 \end{array}$$

Where

$$\begin{aligned} x &= \delta\gamma \\ y &= \delta K \\ z &= K\delta e \\ u &= -K\delta\omega \\ v &= \frac{K\mu\delta T}{(1-e^2)^{\frac{1}{2}}} \end{aligned}$$

The solution of the above equations gave the corrections to the element:—

$$\begin{aligned} \delta\gamma &= +.635 \text{ km.} \\ \delta K &= -.031 \text{ km.} \\ \delta e &= -.015 \\ \delta\omega &= -3^{\circ}.76 \\ \delta T &= -.449 \text{ days,} \end{aligned}$$

and hence the following new elements:—

$$\begin{aligned} \gamma &= +.635 \text{ km.} \\ K &= 32.969 \text{ km.} \\ e &= .265 \\ \omega &= 305^{\circ}.24 \\ T &= 2,417,725.101 \text{ J. D.} \\ P &= 17.355 \text{ days.} \end{aligned}$$

An ephemeris computed with these elements reduces the value of Σprr from 498.94 to 217.35, but the differences found between these residuals and the observation equation residuals were in some cases rather large, and at a suggestion by Mr. Harper—whom I owe much for other valuable suggestions as well—a second solution was made. This time δK was omitted owing to the small correction obtained in the first solution, and the new observation equations contain only four unknowns, and hence only four normal equations follow:—

$$\begin{array}{rcl} 48x & +2'0615y & +1'1149z + 2'0989u + 6'1200 - n = 0 \\ +24'8703y & + '2750z & + '3566u - 9'4127 - n = 0 \\ & +19'7284z & +18'6666u - 5'8754 - n = 0 \\ & & +19'2174u - 4'4691 - n = 0 \end{array}$$

in which

$$\begin{aligned} x &= \delta\gamma \\ y &= K\delta e \\ z &= -K\delta\omega \\ u &= \frac{K\mu\delta T}{(1-e^2)^{\frac{1}{2}}} \end{aligned}$$

The solution gives the corrections:—

$$\begin{aligned} \delta\gamma &= -.137 \\ \delta e &= +.012 \\ \delta\omega &= -1^{\circ}.558 \\ \delta T &= -.0475 \end{aligned}$$

* A. N., 136, 17, 1894.

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The probable error of a normal place of unit weight was computed and found to be ± 3.07 , that of a plate as determined from the residual for each plate scaled from the curve to be ± 5.386 . The probable error of each element was also computed and is attached to the final values below, the values obtained after applying the corrections found in the second least-squares solution:—

$$\begin{aligned}\gamma &= + .498 \text{ km. } \pm .330 \text{ km.} \\ K &= 32.969 \text{ km.} \\ e &= .277 \pm .0012 \\ \omega &= 303^{\circ}.68 \pm 4^{\circ}.25 \\ T &= 2,417,725.054 \text{ J. D. } \pm .187 \\ P &= 17.355 \text{ days} \\ a \sin i &= 7,560,000\end{aligned}$$

These values give a second reduction of Σpvr from 217.35 to 207.7 and satisfactory differences between equation and ephemeris residuals, the average being .08. The curve shown is drawn from the above elements and the circles show the position of the observed normal places.

Since the completion of the foregoing treatment of the binary, from the point of view of the hydrogen lines and the calcium line, λ 3934, all the plates have been reviewed, and the magnesium line λ 4481 carefully measured where measurement was possible, with the intent of determining in what respects the orbit deduced from this line might differ from that already determined from the other lines. The method of treatment was exactly similar to that formerly followed. The period was taken as before—17.355 days. The observations were grouped into normals, the same plates being taken together as in the former treatment and the relative weights assigned as before. The normals were plotted, and the best curve possible drawn through them, or rather the graphic method of Dr. King was employed to obtain the elements of the orbit, the velocity curve corresponding to which best suited these normal places.

The elements thus found were as follows:—

$$\begin{aligned}\gamma &= + 6.69 \text{ km.} \\ K &= 33 \text{ km.} \\ e &= .35 \\ P &= 17.355 \text{ days.} \\ \omega &= 316^{\circ}\end{aligned}$$

Comparing these with the corresponding elements from the other lines, the main differences are seen to be in the values of γ and e .

In the work which has been done on the radial velocities of stars other than binary, some stars have been found, certain of whose lines gave consistently different velocities from other lines. Among them is α Ceti, the emission and absorption lines giving a considerable difference in the value of the radial velocity; so with nearly all Novæ. Nova Aurigæ has been discussed at some length by several astronomers and a similar phenomenon has been noted. Explanations have been suggested as to the cause of the different displacement of different lines. These consist chiefly of two,—first, a lagging envelope producing the lines of less displacement towards the red end of the spectrum, and second, an ever-expanding envelope coming from a continuously productive source. How far such conditions would go to explain a state of affairs such as we find in α Coronæ, it is difficult to say. We may also look upon the system as receding with a velocity of 6.69 km. per second—the velocity given by the magnesium line—and constantly expelling hydrogen and calcium vapors, the velocity of expulsion affected by the periodic recurrence of physical conditions, brought about by the changing relative positions of the stars in the orbit, which conditions fail to influence magnesium in any way so far as changes in the lines are concerned. This is quite plausible, for in

the spectroscopic study of the Sun's surface, regions have been found, such as sun-spots, the spectra of which show certain lines considerably affected in character and position, while other lines denoting other elements remain unchanged.

After the first part of this work had been completed, Mr. Jordan issued from the Allegheny Observatory his publication on the Orbit of α Coronæ Borealis. Comparing his results with those obtained here from the lines $H\epsilon$, $H\gamma$, $H\delta$ and K , it was seen that, although on the whole they agreed fairly well, there was considerable difference in the values of e . This is largely due no doubt to the fact that Mr. Jordan used the line (Mg) $\lambda 4481$, together with the above lines in the determination of his elements. However, the fact that the plates we obtained here were measured by several men and all agreed that the Mg line gave large discrepancies seems to justify the separate treatment.

The accompanying curves represent—Fig. 23, the hydrogen and calcium curve, and Fig. 24 the curve from the hydrogen and calcium lines, and that from the magnesium lines.

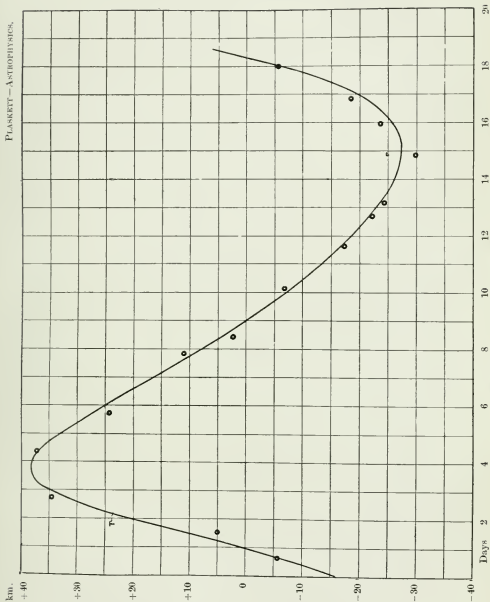


FIG. 23.— α Coronae Borealis, Curve from Hydrogen Lines and Calcium Line.

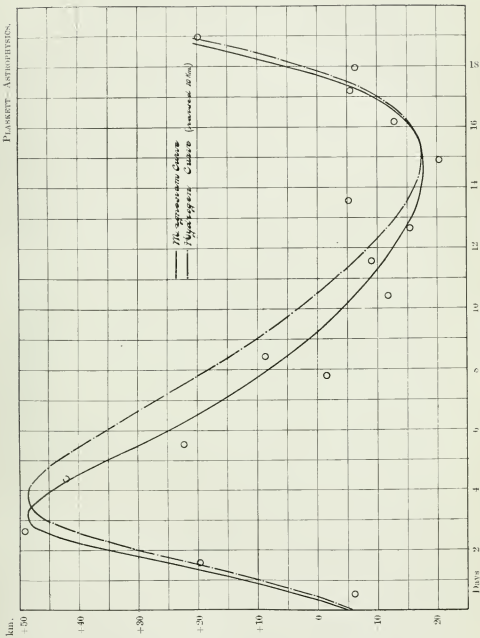


FIG. 24—Velocity Curve of a Coronae Borealis.

APPENDIX C.

THE TWENTY-THREE FOOT SOLAR SPECTROGRAPH.

RALPH E. DELURY.

This instrument is adapted for analyzing with great dispersion the light of the sun and of laboratory sources, such as the electric spark, arc, flame, &c., and is primarily intended for investigating the conditions in the sun. It is situated in the basement of the Observatory in the Solar Research Room, which is connected on the north side by a cement tunnel to the louvred passage of the Coelostat House from which the image of the sun is directed to the spectrograph, and on the east side to the Chemical Laboratory, which is used also as a photographic dark-room in which are developed the photographs of the spectra taken in the spectrograph. The spectrograph may be described under the following heads:—(a) Optical Parts; (b) Mountings; (c) Slit-Attachment; (d) Camera and Plate-Holders; (e) Guide-plate for the Sun's Image.

(a) Optical Parts.

The optical parts are:—a slit with metal jaws 1.3 in. (3.4 cm.) long, mounted so as to leave 1 in. (2.5 cm.) clear, and provided with a micrometer, for adjusting the width of the slit, reading to thousandths of an inch; a six-inch (15 cm.) collimating lens of 22 ft. 10 in. (695.5 cm.) focal length for yellow light; and one of the earlier Michelson plane gratings of speculum metal having a 4.25 in. by 4.75 in. (10.8 cm. by 12 cm.) surface ruled 12,700 lines to 1 in. (500 lines to 1 mm.). These parts are arranged after the plan described by O. Von Littrow in 1863 (see Kayser Handbuch der Spectroscopie 1, 513). In this arrangement the slit is placed at (or near) the focus of the lens and the dispersing system (in this case the grating) is placed on the other side of the lens in such a manner that the dispersed light returns through the lens which focuses it near the slit, as illustrated in Fig. 25, which represents a vertical section through the middle of the spectrograph and mountings. *S* is the slit, *L* the lens, placed at its focal distance from the slit and *G* is the reflecting grating placed just behind the lens *L*, and tilted so that its ruled lines are parallel to the slit. The beam of light to be examined passes through *S* spreading out to fill *L*, which renders it parallel before it reaches *G*, which disperses it and reflects or diffracts it back through *L*. By tilting the top of the grating slightly towards the slit the diffracted light is made to pass back through the lens which focuses it below the slit where it may be examined with an eye-piece or photographed in the plate-holder (*C*). By rotating *G* about a vertical axis on either side of the normal, the different parts of the different orders of spectra are diffracted back through the lens *L*, and by sliding the lens forward or backward the light of the different wave-lengths may be focussed sharply at *C*.

(b) Mountings.

The two tilting movements of the grating mentioned in (a) were provided in the cell of the grating by the John A. Brashear Co., from whom it was purchased. The forward tilt is given by screw *J* and suitable springs pressing against the back of the grating; and a screw placed on the side gives the means for adjusting the lines of the grating parallel to the slit. The grating in the cell rests on the stand *G'*, the axis of which fits into a cylindrical socket in the bottom of

the end, *B*, of the spectrograph, and by turning a handle *K''* (Fig. 26), attached to a worm which works in the toothed sector, *K*, which is attached rigidly to the axis of *G'*, the grating may be rotated about this axis which passes through the centre of the plane of the grating, thus reflecting any desired part of the spectrum of any order through the lens to *C*. By means of the vernier-pointer, *V*, readings to tenths of a degree may be made on the graduated arc *E* and a record of these readings with the corresponding wave-lengths of the spectra reflected to *C* is kept, so that by turning *K''* until *V* points to the proper angle, any desired wave-length may be reflected to the centre of *C* and the grating may be clamped in this position by tightening the screw-clamp *K'*. The lens may be shifted and clamped at any focus by means of the handle *H*, and the position of the pointer *F* is read on a millimetre scale attached to the bottom of *B*, as shown in Fig. 26. Ordinarily the side represented in Fig. 26 is facing downwards and a mirror is placed below the scale and the arc so that the reading may be made conveniently. In addition to these movements of the grating and lens, the mountings permit of rotation of the spectrograph as a whole about its axis, *i.e.*, about the line joining the centre of the slit and the centre of the lens. This idea was suggested by Mr. Plaskett (Report Chief Astronomer for the year ending March 31, 1907, p. 58) and employed by Newall (Monthly Notices 68, 7, Nov., 1907), and used also in the spectrograph mounted vertically and used with the vertical telescope of the Mount Wilson Solar Observatory. It facilitates the study of the rotation of the sun, by enabling the observer to reflect the limbs of the sun at opposite ends of any diameter always tangentially to the slit, as described in detail under (*c*), in Fig. 25, *A* and *B* are the two ends resting on the supports *A'* and *B'* which rest on the cement piers *P* and *P'* built on the cement floor. The end *A* is of half-inch cast brass. It has a V-groove running around its circular rim into which the semi-circular cast-iron support *A'* is bevelled to fit. The back of *A* is a rectangular box 3 in. by 11 in. by 14 in., over which the wooden box *O* is tightly screwed and clamped. The axis of *B*, which is of cast-iron, rests in a cylindrical bearing in the brass support *B'*. The box on *B* projects 3 in. on top and 16 in. on the sides and bottom to give good support for the lens and grating and to provide a surface to which the box *O* is screwed tightly. The bottom of *B* is milled smooth to give easy bearings for the grating and lens mountings. The box *O* is painted black on the inside and is provided with diaphragms, *M*, to prevent as much as possible the diffused light reflected from the lens and grating from striking the photographic plate in the holder, *C*. There is a hinged door, *D*, just above the grating and lens so that these may be conveniently reached.

The spectrograph thus rests at its two ends on the supports *A'* and *B'* on which it may be rotated about its axis. The rim of *A* is toothed (*T*, Fig. 25) and into these teeth fits a gear attached to *T'* (Fig. 27), which is supported in *A'* and which may be turned by means of the handle *T'* (Figs. 27 and 28). The circular face of *A* is graduated in degrees and by means of the vernier attached to *A'* the angle may be read to tenths of degrees. This is necessary in determining the 'East and West' line by allowing the image of the sun to drift across the face of *A* tangentially to some arbitrary line on *A*. From this angle read on the vernier, the position of the diameter of the sun's disc which lies in the plane of the sun's equator, is easily found since the inclination of these two lines to each other at any time is known, and hence the arbitrary line on *A* may be made parallel to any required diameter of the sun's image.

The mountings were constructed by the Victoria Foundry Co. from designs made in accordance with the suggestions of Mr. Plaskett who supervised the construction of the spectrograph. The mechanisms for rotating the grating and the spectrograph were skillfully constructed by Messrs. Mackay and Lucas.

(*c*) Slit-Attachment.

The slit-attachment is shown in Fig. 27. It was designed by Mr. Plaskett and made by the John A. Brashear Co., *a*, *b*, *c*, *d* are 45° reflecting prisms mounted on

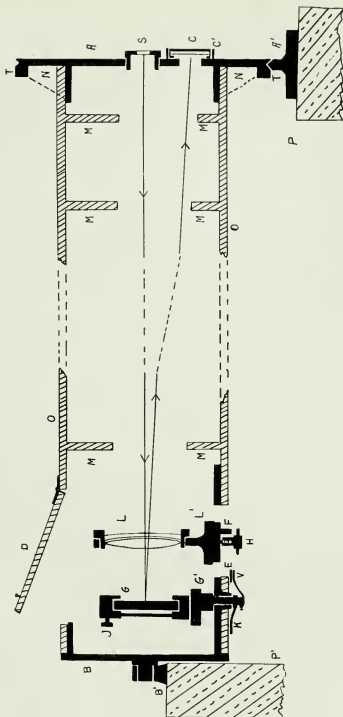


FIG. 25—Solar Spectrograph.

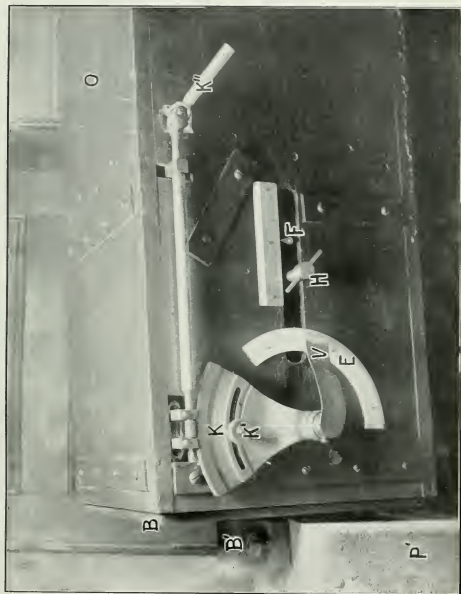


FIG. 26.—Rear end of Solar Spectrograph.

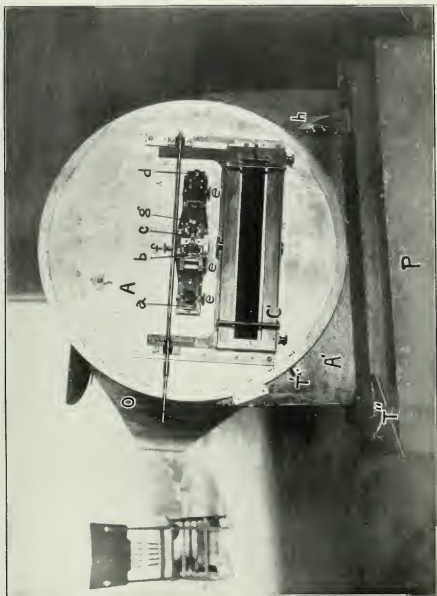


FIG. 27.—Slit Mechanism of Solar Spectrograph.



FIG. 28.—Front End of Solar Spectrograph.

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brass plates which are supplied with racks and pinions *e, e, e*. When the sun's image is placed concentric with the circular front of the spectrograph, the prism *d* is moved to take the light from any desired point near the sun's east limb and reflects it to the prism *e*, which directs it down through the slit to the lens and grating. In a similar way the larger prism, *a*, reflects to the west limb through the prism *b*, whose tapering ends form a V-shaped space into which the tapering end of *c* fits closely, so that the spectrum from the east limb is placed closely between two strips of the spectrum from the west limb. The widths of these strips may be varied by moving the plate holding the prisms *b* and *c* back and forth, and by means of two little slides placed directly over the ends of the slit. When desired the shutter, *f*, may be used to keep the light passing through the slit from reaching the lens. In place of the plate bearing the prisms *b* and *c*, the attachment, *h*, may be used and by means of two adjustable screws which serve as stops between which it may be shifted so that two spectra of any desired widths may be taken in succession, the one being placed between two strips of the other, the V-shaped openings and the V-shaped slides providing the means for adjusting the widths of the strips. The prism arrangement is intended for obtaining plates for measuring the rotation of the sun or for any investigations where it is desirable to take the spectra simultaneously, while the attachment, *h*, is designed for taking spectra in succession, and of course the time of an exposure will be less in using it than in using the prisms which diminish the intensity of the light considerably.

(d) Camera and Plate-holders.

The plate-holders are made to take a 2.5 in. x 12 in. plate, a hinged back with three springs pressing the back of the plate at its edges holding the plate firmly in place without danger of bending it. The plate-holder, *C*, Fig. 28, is slid into the frame *C'*, Fig. 27, and clamped, as shown in Fig. 28. The frame *C'* can be raised or lowered by rack and pinion as shown, so that several strips of spectra may be put side by side on the same plate, and spaced as desired by reference to the millimetre scale on the right hand side. The plate-holder fits over a 1.5 in. opening in *A*, Fig. 27. The frame *C'* may be tilted slightly so that the plane of the photographic plate may be made to follow more closely the focal surface of the lens.

(e) Guide-plate for the Sun's Image.

In Fig. 28 is shown the guide-plate *R*, screwed tightly over the slit-attachment. *R* has a number of concentric circles and a diameter scratched on its surface and blackened so as to be easily visible. These circles are concentric with the circular front of the end-piece *A*. The figure shows the sun's image placed concentric with these circles. At each end of the diameter of these circles is a small rectangular opening, back of which is a little slotted silver-plated shutter which runs in bevelled slides. These shutters may be adjusted by means of the millimetre scales on the edges of the two rectangular openings, so that the slots are tangential to the same circle whose diameter is read off directly, the distance between the nearest ends of the rectangular openings being 200 mm. In the same manner the diameter of the solar image is measured. Back of these slots the prisms are adjusted to give the maximum brightness in the light reflected from the grating, and thus the spectrum from a point in the image near one limit may be placed between two strips of the spectrum from a part of the image at the other end of the diameter. To get any desired latitude on the sun's disc, the image is allowed to drift across the guide-plate tangentially to the diameter—the arbitrary line mentioned above—scratched on the plate and the vernier reading taken of the angle corresponding to this 'east and west line' which makes a known angle at any time with the sun's equator. The handle *T''* is then turned to place the diameter in the desired position. One slit will thus be placed at a certain latitude north of the

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sun's equator and the other at the same latitude south of the equator, and the displacement of the spectral lines resulting therefrom will give a measure of the rotation of the sun in this latitude by turning T'' so that the slits are placed at the same latitude, but on the opposite sides of the equator to those of the former position the same displacement should result if: (1) the sun's equator has been accurately determined, (2) the image in both cases is concentric with the circles on the guide-plate, and (3) the rotation of the sun is the same for the same latitude in both hemispheres. Taking the mean of the two measures from plates taken in succession would eliminate most of the errors introduced.

SOME RESULTS.

The spectrograph was mounted in August, 1908. The cement piers, P , P' (Figs. 26, 27, 28), are made so as to make the axis of the spectrograph coincident with the axis of the concave mirror in the coclostast house, when the image from it is placed in the middle of the face, A , of the spectrograph, P being a few inches higher than P' , giving the proper inclination (about $3\frac{1}{2}^\circ$). The spectrograph was adjusted and numerous test photographs were taken in the various parts from $\lambda 3800$ to $\lambda 6000$. To keep the light reflected back from the surfaces of the lenses from striking the photographic plate the ordinary method of putting a strip across the lens, parallel to the plate, was tried; also, in some tests, the lens was tilted forward so as to throw the reflected light below the photographic plate. This latter method does not alter the character of the lines very much and possesses the advantage of doing away with the strip which masks the central part of the grating and lens. It was soon found that the character of the spectral lines in the different orders from either the left or right inclinations of the grating was not as good as desired. By directly reflected light the grating appears to have three areas of different reflecting powers and it was found that the spectra from these areas did not harmonize. The best spectra were obtained by masking the two smaller areas and using the remaining strip which constituted the right three-fifths of the grating. Even from this part of the grating the spectral lines are poor. In the first and second orders the spectra from the grating tilted to the right are much more intense than those obtained when the grating is tilted to the left, while the reverse is the case in the third order, and furthermore the lines are sharper when the grating is tilted to the left. Consequently the rotation plates obtained were made with the grating tilted to the left and the left two-fifths of the grating masked together with the central strip placed over the face of the lens to cut off the reflected light. The focal curves, for left and right inclinations of the grating were obtained in the first three and part of the fourth orders, for the whole grating with the central strip masked. These are plotted in Fig. 29, the dotted lines being the photographically determined curves and the continuous lines, those visually determined. It will be seen that the locus of the foci for any wave-length in the different orders, instead of being a straight line of constant focus, is a curve (nearly a straight line) of varying focus. This is very likely due to the character of the reflecting surfaces between the scratches on the grating, for it may be assumed that the diamond scratching-point distorted the strips between the scratches in such a way as to make one side of the surface slightly convex and the other slightly concave, as might easily happen since on one side of the diamond-point the speculum is scratched or furrowed, while on the other side it is not. At any rate the grating is not what it should be for the work planned for this spectrograph. This work must necessarily deal with the exact positions and character of the spectral lines and any large or small changes in these. It is chiefly the minute changes that are of interest at present in solar investigations, and the very best possible definition of the spectrum lines is required for a satisfactory measurement of these changes. It is hoped that a new grating of first quality may soon be secured, as such is necessary to yield satisfactory results. Everything else is now in readiness for the careful study of solar problems.

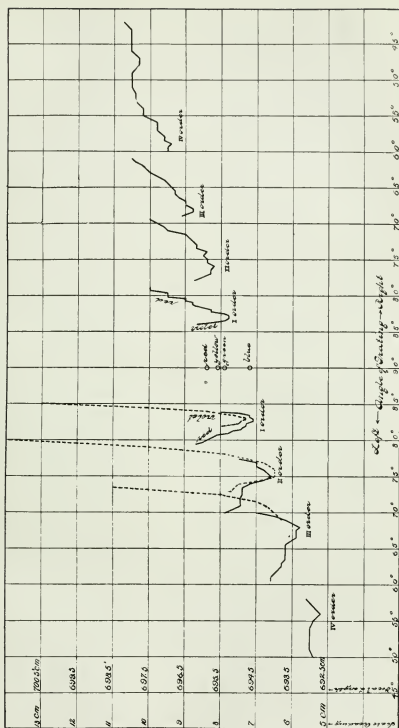


FIG. 29.—Focal Curves of Solar Spectrograph.



K

H

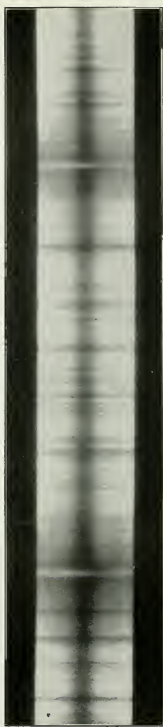


FIG. 30.—Part of Rotation Plate L 413. Scale of the original, 1 A. U. = 1.115 mm.
Part of sun-spot Plate, L 405, showing emission in K and H. Scale of the original 1 A. U. = 1.11 mm.

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In addition to rotation-plates, plates of the sun spot spectra were obtained whenever the conditions were suitable. Samples of both are shown in Fig. 30. In the following table the measurements of a sample rotation-plate (L 413) are given. In taking these plates long exposures (10 or 12 minutes in the third order near 4300) were necessary owing to the fact that a very small area of the grating was used. During this interval the sun's image would become blurred and distorted, thus allowing light from different points on the sun's surface to pass through the slits. The poor values in the following table are probably partially due to this cause and partially also to aberrations produced by some of the curious properties of the grating and to the very poorly defined lines produced. Many of the lines were so poor that measurements of them were not made and many of the finer lines were spread out and weakened so as to be almost invisible. It is hoped that the new grating will remedy these defects.

Measurements of plate L 413, $0^{\circ}.0$, slits 226mm. apart, diameter of the sun 232 mm.:—

| λ | Mean of 5 mm. readings middle strip | Mean of 5 mm. readings lower strip. | Mean of 5 mm. readings upper strip. | Mean difference. | $2\Delta\lambda$ | Velocity km. per sec. |
|-----------|---|---|---|---------------------|------------------|--------------------------|
| 4136.678 | 2.9828 | 3.0314 | 3.0430 | 0.0544 | 0.0488 | 1.77 |
| 4137.156 | 3.5233 | 3.5650 | 3.5931 | .557 | .499 | 1.81 |
| 4140.089 | 6.7876 | 6.8342 | 6.8411 | .500 | .448 | 1.62 |
| 4147.836 | 15.4109 | 15.4623 | 15.4711 | .558 | .500 | 1.81 |
| 4149.533 | 17.2990 | 17.3517 | 17.3520 | .529 | .474 | 1.71 |
| 4150.411 | 18.2771 | 18.3256 | 18.3411 | .513 | .460 | 1.66 |
| 4154.071 | 22.5768 | 22.6215 | 22.6324 | .502 | .450 | 1.62 |
| 4154.667 | 23.0205 | 23.0724 | 23.0828 | .571 | .512 | 1.85 |
| 4154.976 | 23.3789 | 23.4309 | 23.4333 | .532 | .477 | 1.72 |
| 4157.948 | 26.6898 | 26.7408 | 26.7492 | .452 | .405 | 1.46 |
| 4157.948 | 26.6868 | 26.7431 | 26.7558 | .627 | .562 | 2.03 |
| 4158.950 | 27.8144 | 27.8550 | 27.8718 | .490 | .439 | 1.58 |
| 4163.818 | 33.2268 | 33.2824 | 33.2919 | .604 | .542 | 1.95 |
| 4169.110 | 39.1097 | 39.1550 | 39.1763 | .560 | .502 | 1.81 |
| 4171.068 | 41.2803 | 41.3317 | 41.3462 | .587 | .526 | 1.89 |
| 4174.095 | 44.6767 | 44.7188 | 44.7331 | .489 | .438 | 1.57 |
| 4175.806 | 46.6005 | 46.6480 | 46.6549 | .510 | .457 | 1.64 |
| 4176.739 | 47.6361 | 47.6780 | 47.6990 | .524 | .470 | 1.69 |
| 4179.025 | 50.1899 | 50.2346 | 50.2450 | .499 | .447 | 1.60 |
| 4179.025 | 50.1928 | 50.2358 | 50.2405 | .454 | .407 | 1.47 |
| 4181.919 | 53.4290 | 53.4799 | 53.4878 | .571 | .512 | 1.84 |
| 4182.548 | 54.1376 | 54.1827 | 54.1958 | .517 | .463 | 1.66 |
| 4187.204 | 59.3360 | 59.3872 | 59.3987 | .570 | .511 | 1.83 |
| 4187.943 | 60.1723 | 60.2212 | 60.2388 | .577 | .517 | 1.85 |
| 4187.943 | 60.1754 | 60.2208 | 60.2423 | .562 | .504 | 1.81 |
| 4196.372 | 69.5688 | 69.6076 | 69.6247 | .474 | .425 | 1.52 |
| 4199.267 | 72.7938 | 72.8540 | 72.8663 | .664 | .596 | 2.13 |
| 4199.267 | 72.8065 | 72.8626 | 72.8720 | .608 | .545 | 1.95 |
| 4201.089 | 74.8526 | 74.9020 | 74.9137 | .553 | .496 | 1.77 |
| 4202.919 | 76.8960 | 76.9398 | 76.9492 | .485 | .434 | 1.55 |
| 4203.730 | 77.8073 | 77.8667 | 77.8677 | .599 | .537 | 1.92 |
| 4204.622 | 78.7510 | 78.8003 | 78.8116 | .550 | .493 | 1.76 |
| 4207.291 | 81.7826 | 81.8279 | 81.8413 | .520 | .466 | 1.66 |
| 4208.766 | 83.4393 | 83.4904 | 83.4972 | .545 | .488 | 1.74 |
| 4213.812 | 89.0824 | 89.1385 | 89.1469 | .601 | .539 | 1.92 |
| 4216.351 | 91.9078 | 91.9656 | 91.9685 | .593 | .532 | 1.89 |
| 4220.509 | 96.5671 | 96.6150 | 96.6305 | .557 | .499 | 1.77 |
| 4223.328 | 110.4159 | 110.4651 | 110.4745 | .539 | .483 | 1.71 |
| 4226.112 | 113.1064 | 113.1574 | 113.1659 | .553 | .496 | 1.76 |
| 4236.279 | 113.2910 | 113.3460 | 113.3567 | .604 | .542 | 1.92 |
| 4236.279 | 113.2911 | 113.3482 | 113.3563 | .612 | .549 | 1.94 |
| 4238.970 | 116.3636 | 116.4092 | 116.4177 | .499 | .447 | 1.58 |
| 4246.966 | 126.2158 | 126.2723 | 126.2819 | .613 | .550 | 1.94 |
| 4258.774 | 139.0965 | 139.1464 | 139.1514 | .524 | .470 | 1.66 |
| 4265.418 | 147.6064 | 147.6630 | 147.6666 | .584 | .524 | 1.84 |
| 4268.915 | 150.7909 | 150.8440 | 150.8464 | .543 | .487 | 1.71 |
| 4271.325 | 153.4834 | 153.5426 | 153.5484 | .606 | .544 | 1.91 |
| 4271.934 | 154.6638 | 154.7190 | 154.7275 | .595 | .533 | 1.87 |

Measurements of Plate L 413 (Continued).

| | Mean of 5 mm. readings middle strip | Mean of 5 mm. readings lower strip | Mean of 5 mm. readings upper strip. | Mean difference. | $2\delta\lambda$ | Velocity km. per sec. |
|----------|---|--|---|---------------------|------------------|--------------------------|
| 4274-958 | 157-5662 | 157-6159 | 157-6230 | 0-0533 | 0-0478 | 1-68 |
| 4279-643 | 162-8316 | 162-8856 | 162-8923 | 574 | 515 | 1-81 |
| 4282-565 | 166-1090 | 166-1575 | 166-1650 | 523 | 469 | 1-64 |
| 4283-169 | 166-7867 | 166-8456 | 166-8437 | 580 | 520 | 1-82 |
| 4287-566 | 171-7201 | 171-7671 | 171-7684 | 477 | 427 | 1-49 |
| 4288-310 | 172-5555 | 172-6182 | 172-6188 | 630 | 565 | 1-98 |
| 4289-525 | 173-9153 | 173-9697 | 173-9714 | 553 | 496 | 1-73 |
| 4289-885 | 174-3185 | 174-3698 | 174-3829 | 579 | 519 | 1-82 |
| 4290-080 | 174-8803 | 174-9256 | 174-9400 | 525 | 475 | 1-66 |
| 4390-377 | 175-0671 | 175-1189 | 175-1266 | 557 | 499 | 1-74 |
| 4291-114 | 176-2785 | 176-3263 | 176-3375 | 534 | 479 | 1-67 |
| 4295-383 | 181-0754 | 181-1309 | 181-1437 | 619 | 555 | 1-94 |
| 4300-211 | 185-9150 | 185-9642 | 185-9754 | 548 | 491 | 1-71 |
| 4300-211 | 184-7011 | 184-7533 | 184-7603 | 557 | 499 | 1-74 |
| 4302-692 | 187-4850 | 187-5400 | 187-5453 | 577 | 517 | 1-80 |
| 4312-462 | 200-4632 | 200-5002 | 200-5203 | 571 | 512 | 1-78 |
| 4316-962 | 205-6104 | 205-6557 | 205-6737 | 543 | 487 | 1-69 |
| 4320-907 | 207-9588 | 207-9978 | 207-0193 | 498 | 446 | 1-55 |
| 4321-119 | 208-1885 | 208-2350 | 208-2553 | 567 | 508 | 1-76 |
| 4331-811 | 230-2219 | 230-2719 | 230-2817 | 549 | 492 | 1-71 |
| 4337-216 | 226-3078 | 226-3617 | 226-3729 | 595 | 533 | 1-85 |
| 4338-084 | 227-2934 | 227-3348 | 227-3580 | 530 | 475 | 1-64 |
| 4338-430 | 227-6796 | 227-7315 | 227-7403 | 563 | 505 | 1-75 |
| 4339-617 | 229-0152 | 229-0619 | 229-0751 | 533 | 478 | 1-65 |
| 4339-882 | 229-3068 | 229-3559 | 229-3787 | 605 | 542 | 1-87 |
| 4343-861 | 233-7958 | 233-8477 | 233-8647 | 604 | 542 | 1-87 |
| 4344-451 | 234-4621 | 234-5066 | 234-5309 | 567 | 508 | 1-74 |
| 4344-670 | 234-7022 | 234-7509 | 234-7669 | 567 | 508 | 1-75 |
| 4344-670 | 234-7023 | 234-7510 | 234-7679 | 572 | 513 | 1-77 |
| 4351-216 | 242-0735 | 242-1259 | 242-1400 | 595 | 533 | 1-84 |
| 4351-216 | 242-0719 | 242-1223 | 242-1343 | 564 | 506 | 1-74 |
| | | | | | Mean.... | 1-77 |

The scale, which is practically constant over the whole plate, is 1 A. U. = 1.115 mm., hence $2\delta\lambda = \frac{\text{mean difference}}{1.115}$. The velocity is $\frac{\delta\lambda}{\lambda}$ (Velocity of light) = $299860 \frac{\delta\lambda}{\lambda}$ km. per second. Heliographic latitude of the centre of the sun's disc was $6^\circ 26'$ when plate L 413 was taken, consequently the velocity at the equator, as determined by this plate is $\frac{232}{226} \cdot 1.77 \cdot \frac{1}{\cos 6^\circ 26'} = 1.83$ km. per second. This value is the linear velocity of the sun's limit at the equator, as measured, and will evidently give the synodic period of the rotation, the value for which is 1.86, as given by Adams. To reduce to the sidereal period requires the addition of 0.14 km., making the velocity 1.97 km. The generally accepted value is approximately 2.05 km. per second, and the deficiency in the present case may be safely ascribed to errors introduced by the grating.

APPENDIX D.

DOUBLE STAR MEASURES. PHOTOGRAPHS OF COMET MOREHOUSE.
OCCULTATIONS OF STARS BY THE MOON. FIELD INSTRUMENTS.
ABERRATIONS OF THE STELLAR CAMERA OBJECTIVE.

R. M. MOTHERWELL.

DOUBLE STAR MEASURES.

Three half nights each week have been devoted to micrometer and photographic work, including the series of tests made on the camera objective. Micrometer work has consisted principally of the determination of the position angles and distances of visual double stars, the working list being prepared from Burnham's Catalogue of Double Stars. An endeavour is being made to measure only those which have not been measured for some time or whose motion is such as to require frequent measurements.

The filar micrometer used, is the Warner and Swasey type, and it has been found rather unsatisfactory in the determination of position angles owing to there being no quick-motion screw for moving the position circle. A self-registering attachment would be a great improvement as the present arrangement requires the frequent use of a hand-lamp which dazzles the eye. Considerable difficulty has also been experienced in keeping the eye-piece clear of frost in the winter, each setting of the micrometer-head or position-circle requiring several clearings of the glass.

Following are the measures made during the past year, each measure being the mean of eight settings for position angle and four double-distance measures:—

| Star No. | Date. | Position Angle. | Distance. | Star No. | Date. | Position Angle. | Distance. |
|-----------|----------|-----------------|------------|-----------|----------|-----------------|-----------|
| 151..... | 1908 786 | 279 0 | 1 34 | 7117..... | 1908 464 | 298 2 | Cloudy. |
| 269..... | 1908 765 | 113 9 | 5 78 | 7318..... | 1908 317 | 184 3 | 3 81 |
| 1427..... | 1908 921 | 313 9 | 3 28 | ..... | 1908 575 | 186 8 | 4 01 |
| 1750..... | 1908 921 | 249 1 | 17 24 | ..... | 1909 429 | 252 9 | 9 39 |
| 2040..... | 1908 921 | 218 8 | 4 21 | ..... | 1908 575 | 15 2 | 8 70 |
| 2043..... | 1908 921 | 328 5 | ..... | ..... | 1908 617 | 14 3 | 9 21 |
| 2536..... | 1908 996 | 305 3 | 2 73 | ..... | 1908 631 | 14 0 | 9 53 |
| 3398..... | 1908 996 | 6 4 | ..... | ..... | 1909 412 | 14 9 | 8 91 |
| 4452..... | 1909 341 | 43 3 | 2 60 | ..... | 1909 429 | 13 9 | 9 32 |
| 4539..... | 1909 086 | 139 6 | 6 12 | 7451..... | 1908 317 | 255 4 | 16 64 |
| 4890..... | 1908 247 | 196 9 | 5 14 | ..... | 1908 464 | 254 1 | 17 11 |
| ..... | 1909 086 | 196 7 | 4 88 | ..... | 1908 575 | 254 8 | 16 57 |
| ..... | 1909 303 | 197 0 | 5 11 | ..... | 1908 617 | 256 0 | 16 17 |
| 5011..... | 1908 247 | 45 5 | 1 88 | ..... | 1908 631 | 254 6 | 16 65 |
| 5014..... | 1909 202 | 235 9 | 3 50 | 7458..... | 1908 575 | 288 9 | 3 21 |
| ..... | 1909 393 | 234 0 | 3 39 | 7604..... | 1908 464 | 211 9 | 17 12 |
| ..... | 1909 341 | 235 5 | 3 40 | ..... | 1908 497 | 211 9 | 16 89 |
| 5125..... | 1908 394 | 146 5 | 3 43 | ..... | 1908 575 | 214 0 | 16 59 |
| 5319..... | 1908 394 | 176 9 | 2 50 | 7642..... | 1908 575 | 89 8 | 1 77 |
| ..... | 1908 426 | 177 3 | 2 78 | 7915..... | 1908 439 | 18 2 | 5 03 |
| 5337..... | 1908 977 | 295 2 | 36 78 | ..... | 1909 492 | 20 6 | 5 38 |
| ..... | 1909 183 | 294 4 | 31 50 | ..... | 1908 617 | 18 4 | 5 48 |
| ..... | 1909 202 | 294 8 | 31 89 | 5388..... | 1908 247 | 117 4 | 3 88 |
| ..... | 1909 399 | 294 3 | 31 09 | ..... | 1908 426 | 115 5 | 3 43 |
| 6780..... | 1909 183 | 353 4 | Too frosty | | 1909 183 | 114 1 | 3 89 |
| 7065..... | 1909 183 | 111 1 | " | | 1909 399 | 116 4 | 3 82 |

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| Star No. | Date. | Position Angle. | Distance. | Star No. | Date. | Position Angle. | Distance. |
|----------|----------|-----------------|-----------|----------|----------|-----------------|-----------|
| 5126. | 1908-247 | 68-6 | 3-05 | 9034. | 1908-641 | 338-7 | 27-47 |
| 5705. | 1909-303 | 68-1 | 3-50 | 9037. | 1908-765 | 339-3 | 26-60 |
| 5809. | 1909-399 | 66-5 | 3-27 | 9037. | 1908-541 | 51-9 | 7-84 |
| 5809. | 1909-303 | 32-2 | 3-37 | 9037. | 1908-581 | 50-5 | 8-50 |
| 5809. | 1908-977 | 27-6 | 24-86 | 9037. | 1908-541 | 7-41 | 5-90 |
| 5809. | 1909-078 | 28-0 | 25-17 | 9037. | 1908-581 | 7-33 | 5-88 |
| 5809. | 1909-086 | 30-7 | 24-90 | 9037. | 1908-641 | 7-24 | 5-68 |
| 5809. | 1909-202 | 27-6 | 24-89 | 9037. | 1908-765 | 7-12 | 5-91 |
| 5809. | 1909-303 | 28-3 | 25-33 | 9167. | 1908-541 | 154-8 | 0-84 |
| 6030. | 1908-426 | 308-5 | 2-80 | 9167. | 1908-613 | 154-5 | 0-89 |
| 6033. | 1908-426 | 108-8 | 6-28 | 9604. | 1908-541 | 9-7 | 2-81 |
| 6033. | 1909-078 | 107-8 | 5-72 | 9604. | 1908-613 | 10-5 | 2-75 |
| 6033. | 1909-202 | 106-8 | 6-06 | 9693. | 1908-492 | 138-6 | 4-07 |
| 6033. | 1909-303 | 106-7 | 6-57 | 9693. | 1908-522 | 138-0 | 3-74 |
| 6033. | 1909-078 | 178-9 | 16-32 | 9693. | 1908-575 | 138-3 | 4-01 |
| 6033. | 1909-086 | 181-7 | 16-10 | 9693. | 1908-581 | 138-6 | 3-93 |
| 6033. | 1909-183 | 179-3 | 16-50 | 9693. | 1908-613 | 137-8 | 4-31 |
| 6033. | 1909-399 | 179-4 | 16-41 | 9693. | 1908-600 | 271-1 | Cloudy. |
| 6211. | 1908-426 | 359-2 | 2-60 | 9693. | 1908-600 | 155-7 | 4-31 |
| 6386. | 1909-360 | 119-0 | 2-99 | 9693. | 1908-641 | 170-1 | 3-50 |
| 7927. | 1908-617 | 127-0 | 33-08 | 9693. | 1908-765 | 171-0 | 7-18 |
| 7927. | 1908-631 | 125-3 | 33-24 | 9693. | 1908-786 | 171-8 | 3-51 |
| 7927. | 1909-429 | 126-5 | 33-21 | 9693. | 1908-765 | 185-3 | 1-89 |
| 7930. | 1908-617 | 180-8 | 24-94 | 9693. | 1908-613 | 212-2 | 3-39 |
| 7930. | 1908-631 | 180-5 | 24-93 | 9693. | 1908-522 | 74-2 | 5-68 |
| 8093. | 1908-309 | 312-4 | 4-15 | 9693. | 1908-581 | 111-0 | 5-60 |
| 8093. | 1908-445 | 313-3 | 4-17 | 9693. | 1908-522 | 164-6 | 5-91 |
| 8082. | 1908-309 | 22-8 | 8-11 | 9693. | 1908-613 | 158-3 | 3-09 |
| 8082. | 1908-426 | 22-6 | 7-98 | 9693. | 1908-613 | 349-2 | 22-90 |
| 8082. | 1908-439 | 25-4 | 7-91 | 9693. | 1908-765 | 351-5 | 23-80 |
| 8082. | 1908-445 | 24-4 | 7-95 | 9693. | 1908-522 | 309-3 | 3-37 |
| 8303. | 1908-309 | 258-5 | 2-67 | 9693. | 1908-511 | 307-9 | 3-71 |
| 8303. | 1908-445 | 258-7 | 2-53 | 9693. | 1908-581 | 307-5 | 3-44 |
| 8303. | 1908-617 | 259-7 | 2-71 | 9693. | 1908-786 | 307-8 | 3-18 |
| 8364. | 1908-617 | 81-6 | 2-87 | 9693. | 1908-805 | 308-8 | 5-68 |
| 8364. | 1908-746 | 78-2 | 2-70 | 9693. | 1908-613 | 112-6 | 5-60 |
| 8364. | 1908-765 | 79-4 | 3-00 | 9693. | 1908-641 | 112-0 | 5-91 |
| 8364. | 1909-429 | 78-2 | 1-49 | 9693. | 1908-765 | 34-3 | 3-09 |
| 8384. | 1908-624 | 79-0 | 27-15 | 9693. | 1908-765 | 160-1 | |
| 8404. | 1908-631 | 338-4 | | | | | |

COMET 1908C (MOREHOUSE).

This comet was visible for over three months, but dense smoke and unusually cloudy weather prevented any attempt at obtaining an extensive series of photographs. Single exposures were made on seven different nights, with the Brashear Doublet attached to the equatorial telescope. A filar micrometer was used in guiding and was very satisfactory in preventing drifting but, owing to the smallness of its field, did not permit of the head of the comet being shifted appreciably from the centre of the camera field. Had it been possible to so shift the head, more of the tail would have been included in the photograph.

The following table gives the date and duration of each exposure:—

| Plate. | Eastern Standard Time. | Beginning of Exposure. | Duration. | Remarks. |
|--------|------------------------|------------------------|-----------|---------------------|
| 31. | 1908, October 16. | h m | h m | Very smoky. |
| 32. | " 19. | 6 45 | 1 0 | " |
| 33. | " 31. | 6 10 | 1 5 | Clear. |
| 34. | November 1. | 7 25 | 0 55 | Clear but unsteady. |
| 35. | " 13. | 7 15 | 1 0 | Very clear. |
| 36. | " 26. | 6 15 | 1 25 | Clear, high wind. |



FIG. 31 & 32—Morehouse's Comet.



FIG. 33 & 34—Morehouse's Comet.



FIG. 35 & 36—Morehouse's Comet.

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An exposure of one hour was made on October 20, but the smoke was too dense. In the course of the exposure the head of the comet passed over an eighth magnitude star without perceptibly dimming it.

Fig. 31. The dense smoke accounts for the faintness of this photograph, but still it is the most interesting one of the set, on account of the knots in the tail about one and a half degrees from the head. This portion seems to have separated from the head and drifted off while new matter has been given out. There has also probably been a motion southward on the part of this detached mass, greater than that of the comet as the new matter in the tail connects with the north side of the knots, while the southern part is altogether clear of the tail. The curved form of the central and southern portions of the detached mass is also worthy of notice. The new matter is connected to the head by a narrow neck and on either side rays extend back about 0.5 degrees.

Fig. 32. This photograph is even more faint than Fig. 31, but the head shows considerable detail. The new portion of the tail spoken of in Fig. 31 has apparently been forced back by the rays on either side, they being joined together now just back of the head. Although only three days have elapsed between these exposures we can readily see that, during this interval, the comet has been very active internally.

Figs. 33 and 34 indicate a continuation of this activity. Fig. 33 shows several distinct knots in the tail about one to one and a half degrees from the head. Beyond these the tail gradually widens out, being uniform on the north side but broken on the south side. Fig. 34, one day later, shows the same knots farther away from the head and more diffused. They seem to have been separated from the nucleus, the bright portion next to the head in Fig. 33 broadening out here into a fan-shaped tail. Beyond the knots the tail has widened slightly.

Fig. 35 shows a very bright tail extending out about two degrees with short rays on both sides of the head. As in Fig. 33 the north side of the tail is uniform, while the south side shows several offshoots. The comet was apparently in a very active state at this time, but thirteen days elapsed before I had an opportunity for another exposure, and Fig. 36 shows a much fainter and divided tail. Evidently the activity has become much less, the faintness of the tail being partly due to its division into two parts, but more particularly to a change in the conditions governing the state of the comet's head. Are these changes in appearance due to some internal state or are they due to changes in the surrounding medium?

While this set of photographs can lay no claim to completeness, it demonstrates clearly the necessity for frequent exposures at as close intervals as possible if we wish to know with any degree of accuracy the changes actually taking place. It also shows that these exposures should not be too long, otherwise one plate might be a combination of several phases.

No other comets were visible here in 1908, but several exposures were made toward the close of the year in search of Halley's comet. The end of July or the early part of August, 1909, should see the discovery of this famous celestial visitor. Photography will doubtless first reveal its presence and on account of this it is desirable that the stellar camera should be available for work every night. With the present mounting of the camera this means the suspending of all work with the equatorial at such times when the comet may be observed. This is much to be regretted as both the equatorial telescope and the camera are excellent instruments, and it is hoped that a separate mounting may be provided for the camera at an early date. Halley's comet will not return for at least seventy-five years, but every year brings with it new comets; so if our Dominion Observatory is to take a foremost place in the discovery and study of these strange visitors, the equipment necessary for camera work should be provided at once.

OCULTATIONS OF STARS BY THE MOON.

The observations of occultations have been made mostly with the 15-inch equatorial telescope as its superior mounting and clock-work render it much more satisfac-

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tory than the $\frac{4\frac{1}{2}}$ -inch Cooke telescope. Predictions have been made by the graphical method of Wm. F. Rigge, but less than 10 per cent of the predicted occultations were observed owing to cloudy weather. Following are the observations:—

OCCULTATIONS OF STARS BY THE MOON.

| Date. | Phenomenon. | Star. | Limb. | G.M. Time of observation. | | |
|-----------------|--------------------|--------------------------|-------------|---------------------------|----|------|
| | | | | h. | m. | s. |
| 1908. | | | | | | |
| April 9..... | Disappearance..... | γ Cancri..... | Dark..... | 6 | 53 | 53.2 |
| " 13..... | "..... | γ Virginis..... | "..... | 7 | 2 | 55.6 |
| | Reappearance..... | "..... | Bright..... | 8 | 8 | 36.5 |
| June 11..... | Disappearance..... | α^1 Librae..... | Dark..... | 13 | 44 | 23.3 |
| " 12..... | "..... | γ^2 Scorpii..... | "..... | 11 | 28 | 11.1 |
| | Reappearance..... | "..... | Bright..... | 12 | 0 | 16.8 |
| October 13..... | Disappearance..... | α Tauri..... | "..... | 16 | 52 | 41.0 |
| November 1..... | "..... | γ Capricorni..... | Dark..... | 5 | 30 | 1.8 |
| 1909. | | | | | | |
| January 7..... | "..... | γ Cancri..... | Bright..... | 12 | 19 | 15.8 |
| March 12..... | "..... | β^1 Scorpii..... | "..... | 16 | 35 | 6.1 |
| | Reappearance..... | "..... | Dark..... | 17 | 25 | 37.8 |
| | Disappearance..... | β^2 Scorpii..... | Bright..... | 16 | 35 | 59.7 |
| | Reappearance..... | "..... | Dark..... | 17 | 24 | 50.0 |
| March 14 | Disappearance..... | β^3 Ophiuchi..... | Bright..... | 16 | 12 | 3.1 |
| | Reappearance..... | "..... | Dark..... | 17 | 30 | 57.4 |

INSTRUMENTS USED ON THE BOUNDARY AND GEODETIC SURVEYS.

The instruments used on these surveys have all been carefully catalogued and stamped, an index system being used which shows the office number, description of instrument, price, date of receipt, name of maker, location and disposal of each instrument. A separate account is also kept of the instruments as taken out by each party in the spring, so that each man can readily see what instruments he is held responsible for.

Following is a list of the principal instruments used during the season of 1908:—

| Name of Instrument. | Number Used. | Name of Instrument. | Number Used. |
|---------------------|--------------|---------------------|--------------|
| Barometers..... | 20 | Heliotropes..... | 8 |
| Balances..... | 5 | Levels..... | 11 |
| Binoculars..... | 18 | Plane Tables..... | 5 |
| Cameras..... | 18 | Sextants..... | 2 |
| Chronometers..... | 14 | Tapes..... | 25 |
| Clinometers..... | 4 | Telescopes..... | 9 |
| Compasses..... | 25 | Transits..... | 47 |

ABERRATION OF THE STELLAR CAMERA OBJECTIVE.

The stellar camera used in the Dominion Observatory, Ottawa, for photographing star clusters, nebulae, comets, or any other celestial objects covering a wide field, is fitted with a Brashear photographic doublet of 203mm. aperture and 1060.3mm. focus. The camera tube (Fig. 37) is bolted to the telescope tube opposite to its place of attachment to the declination axis. This method of mounting is rather unsatisfactory, however, as the telescope tube intercepts a large portion of the light on the west side of the plate.

The effective field has a diameter of about $11^\circ 20'$, so the camera is well adapted in this respect to its work. The tube containing the objective is nickelled and moves freely in the main metal tube, the position of focus being adjusted by a rack and pinion with a clamp screw to hold it in the required position. This position is read on

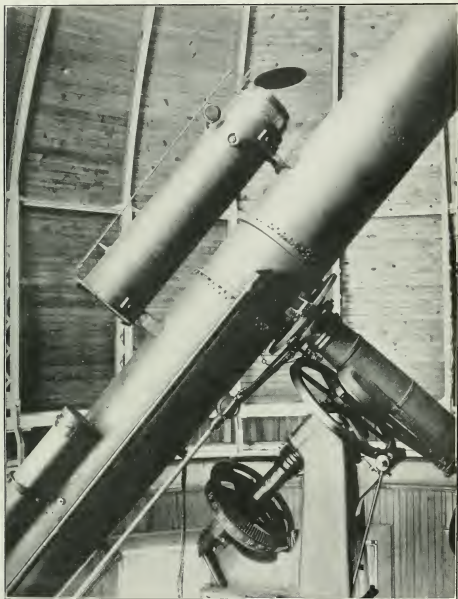


FIG. 37—Stellar Camera.

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a millimetre scale. A metal shutter covers the objective and the plates are held in a metal frame fitted with springs. When accurate guiding is required the micrometer wires in the telescope are used, the great focal length of the refractor, as compared with the camera, rendering the guiding a simple matter.

The following description of the lens is given by Dr. Brashear:—

'The general construction is that which was first found by Petzval years ago, and has proven itself quite the best, where great angular aperture with sharp definition is required. The curves have been somewhat modified from our experience in the construction of other lenses—particularly those made for Dr. Max Wolf, of Heidelberg, Germany. It departs, however, from the ordinary practice of opticians in being corrected for short wave-lengths of light. This would be quite objectless in a camera which is to be used for portraits, but is not without moment in astronomical photography. The materials employed were specially chosen for their transparency, the flint being very light and the crown very white. The focal lengths of the front and rear combinations are in a ratio of about 7 to 12, while the focal length of the system is very nearly five times the aperture. The focal length we may find very slightly modified: indeed it is our custom to balance the inevitable zonal differences of magnification, which difficulty is found the most formidable to all constructors of astronomical photographic objectives.'

The camera gives a more uniformly defined field than most cameras of this type, but the definition is not sufficiently sharp to produce clear cut images. When a long exposure is made to reach faint stars there are three resulting forms of image. The fainter stars give a clear cut image, the next in brightness give an image with a dark centre surrounded by a halo, while the brighter stars give an image of uniform density but much enlarged. This variation in the images must be due to aberration, either spherical or chromatic, producing, instead of point images, discs of sensible size, possibly with a centre somewhat more intense than the surrounding portion. The difference in the appearance of the images of stars of different brightness on the negative is thus readily explained by the light of the fainter stars not being sufficient to form a halo, as in the next brighter stars, while in the very bright stars the light is strong enough to make the halo as dense as the central portion. The only question is whether this aberration is spherical or chromatic.

The most simple test for the presence of zonal errors in a lens is that of Hartmann, the theory involved being very simple, and the equipment for the experiment

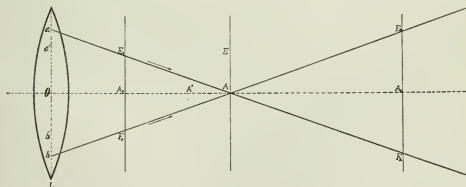


FIG. 38.

being within reach of any one. This method involves the determination of the point of intersection of rays of light passing through the lens at opposite ends of a diameter and equidistant from the centre.

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Let L (Fig. 38) be the lens under test and consider two rays passing through a, b , so that $Oa = Ob$. These rays converge to a point A which is called the focus of these rays. If these rays are intercepted at A we find them in a single point, but if intercepted at E_1 or E_2 we find them separated by a distance d_1 or d_2 . These distances may be measured with a micrometer, or photographic plates may be placed at E_1, E_2 , and the distances between the resulting images measured. This latter method has been employed in the present test.

Measuring the distances OA_1, OA_2 and d_1, d_2 , we can easily obtain the correct position of focus.

$$\begin{aligned} \text{Let } OA_1 &= A_1 & E_1 F_1 &= d_1 \\ OA_2 &= A_2 & E_2 F_2 &= d_2 \\ OA &= A \end{aligned}$$

Then $A = A_1 + \frac{d_1}{d_1 + d_2} (A_2 - A_1)$. This is a simple geometrical property requiring no proof.

Again, consider two rays passing through at a', b' . If the lens is correctly ground these two rays will converge to the point A as did a and b , and so with rays from all parts of the lens. But unfortunately this is a difficult condition to obtain, the best of lenses being but a close approximation to it. In place of converging to A , a' and b' converge to some other point, say A' , giving what is called zonal aberration, so that if we focus our camera for a and b , it is out of focus for a', b' , and we get a disc about our image.

Take two rays at a distance Oa from the centre but on a diameter perpendicular to a, b , and consider their focus. If the lens is symmetrical for this zone, then the four rays will meet at the point A , their common focus, but if not symmetrical there will be two different foci for the two pairs of rays. This difference is called axial astigmatism and can be revealed in the Hartmann test for aberration.

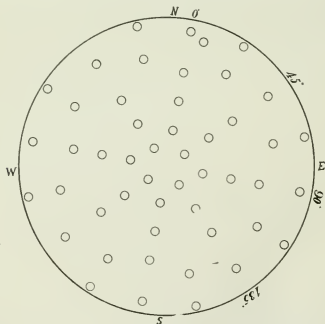


FIG. 39—Zonal Disc.

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The lens is covered with a zone plate of the form shown in Fig. 39. The apertures are placed in ten zones of 15, 25, 35, 45, 55, 65, 75, 85, 94 and 98 mm. radius respectively. Each pair of openings is duplicated by a second pair at right angles in order to determine the axial astigmatism. In the case of the zones of 15, 25, 35, 45, 55, 65, 85 and 94 mm. radius, symmetrical pairs of apertures are placed 90° apart, but in the zones of 75 and 98 mm. radius the apertures are only 45° apart, so the outer part of the lens is more thoroughly tested than the centre. This is necessary owing to the greater amount of light admitted by the outer zones.

By making an exposure at E_1 and another at E_2 , we can determine two positions of focus for each of the ten zones, these two positions being perpendicular to each other. An extra aperture in the zone plate enables one to identify the angle for the several zones and so avoid confusion in the determination of astigmatism.

The first zone plate used had apertures of 10 mm., but the diffraction at the edges was so great that in place of solid dark spots there were circular dark rings which did not permit of accurate measurement. The second zone plate used had a diameter of 203 mm. with apertures of 5.5 mm. These plates were made of medium weight bristol board. Exposures of 6 minutes were made on Capella. In order to avoid as much as possible chromatic aberration, Seed Process plates were used, their band of sensitiveness being narrow and confined chiefly to the blue and violet light beyond λ 4600. A plate with a wider range of sensitiveness would give images so elongated radially by chromatic aberration as to render accurate measurements very difficult or impossible.

All measures were made on the Zeiss comparator, the graduations reading to thousandths of a millimetre and readily estimated to ten thousandths. Test plates were first made with 4 x 5 Seed plates, to determine the correct time of exposure, a plate-adaptor being used in the regular plate-holder. The positions corresponding to E_1 and E_2 were at 22 mm. and 67 mm., respectively, on the focussing scale on the camera tube. This gave the distance $A_2 - A_1$, equal to 45 mm. In the appended results the focus given is that which would be used in setting according to the above mentioned scale. The actual focus of the camera was determined as follows:—The telescope was set midway between Castor and Pollux and a photograph taken, with the camera at its usual focus (47.5 mm. on the scale) and the zone plate removed. The distance between the images on the photographic plate was measured and found to be $d = 79.5260$ mm.

From the Ephemeris we have—

| R. A. | Dec. |
|--|--------------------------|
| Castor, $7^h 28^m 43^s.9$ | $+ 32^\circ 5' 28''.13$ |
| Pollux, $7^h 39^m 41^s.284$ | $+ 28^\circ 14' 56''.34$ |
| The difference in R. A. is $0^h 10^m 57^s.384 = 2^\circ 44' 20''.76$ | |
| Zenith distance of Castor is $57^\circ 54' 31''.87$ | |
| Zenith distance of Pollux is $61^\circ 45' 3''.6$ | |
| From $\cos a = \cos b \cos c + \sin b \sin c \cos A$, we have $a = 4^\circ 30' 48''$ = the distance between Castor and Pollux. | |

Hence, from the cotangent of a and the value of d we have the focus required

$$f = 1060.3 \text{ millimetres.}$$

When the correct time of exposure had been obtained, the regular 8 x 10 plates were used and a series of exposures made at E_1 and E_2 . Although the original object in view was to test for spherical aberration at the centre, this was extended to cover the whole field of the lens and images were made extending across the plate from south to north, in order to determine the curvature of field. Nine images were obtained within the focus and nine without, their respective positions being:—

| | | |
|-------------|------------|--------------------------------|
| Position A, | 5°.3 | from centre towards south end. |
| " B, | 4° | " " " " |
| " C, | 2°.5 | " " " " |
| " D, | 1° | " " " " |
| " E, | at centre. | |
| " F, | 1° | from centre towards north end. |
| " G, | 2°.5 | " " " " |
| " H, | 4° | " " " " |
| " I, | 5°.5 | " " " " |

Owing to the uncertainty of the weather, exposures at positions A, B, C, D and E were made on one plate without the focus, and then exposures were made on another plate at the same positions within the focus. Exposures at F, G, H and I were then made on two other plates. This unfortunately caused a slight change in the adjustment of the camera and the result was an unaccountable dip in the curvature of the field. Further test plates were made at positions E, F and H, which showed clearly that the dip was not due to any fault of the lens, the resulting curve being quite uniform, as shown in Figs. 43 and 44.

The several plates were first measured for aberration and astigmatism. A summary of the results is given in the appended tables and curves. As stated before, the positions E_1 and E_2 correspond to 22 mm. and 67 mm. on the scale attached to the camera. The camera was set at 47.5 mm. to determine the focus $f = 1060.3$ mm. So we have $A = 1034.8$ mm. and $A_2 - A_1 = 45$ mm. To obtain the actual focus for each zone in the following results we must add 1034.8 mm. to each given focus.

| | |
|------------|---|
| Position A | shows a negative aberration of 3.61 mm. |
| " B | " " " " 3.82 mm. |
| " C | " " " " 3.75 mm. |
| " D | " " " " 3.63 mm. |
| " E | " " " " 3.60 mm. |
| " F | " " " " 3.63 mm. |
| " G | " " " " 3.64 mm. |
| " H | " " " " 3.82 mm. |
| " I | " " " " 3.63 mm. |

Such a marked aberration, extending so uniformly across the field, shows beyond any doubt the cause of the diffuse appearance of the images already referred to. The curves in Figs. 40 and 41, each division representing 1 millimetre, show very clearly the magnitude of the aberration and its uniformity across the field from south to north. Another plate R, made on the east side of the field, shows a similar aberration, curve P, Fig. 42, representing it graphically.

Taking the mean focus for each zone we find the astigmatism so small as to be neglected at the centre of the field but increasing as we move outward. A closer examination reveals the fact that where $\varphi = 0^\circ, 90^\circ, 67^\circ.5$ and $157^\circ.5$, the astigmatism is the greatest. This is due to the varying angle of incidence of the rays on the plate in the several positions A, B, C, etc. This variation in angle affects the distance between the images in the respective zones inversely as the angles they make with the north and south line. Thus (see Fig. 39) when $\varphi = 0^\circ$, the change in distance is greatest; when $\varphi = 90^\circ$, the change in distance is least; when $\varphi = 45^\circ$, the change is almost the same as when $\varphi = 135^\circ$. So we see that the apparent variation in astigmatism is due to the position of the plate and consequent distortion of some of the images rather than to any defect in the lens.

As already stated, the Seed Process plate used has its maximum sensitiveness about λ 4300 in the blue light. Thinking perhaps the lens had originally been tested with yellow light, owing to the difficulty of obtaining monochromatic light in the blue, it was consequently decided to test the lens by visual or yellow light. Cramer Iso-

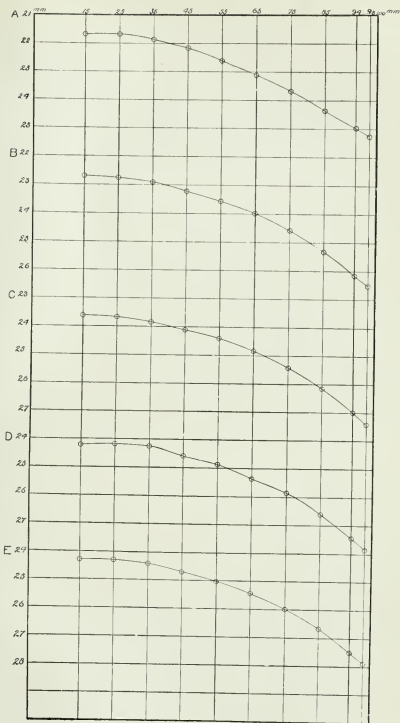


FIG. 40—Zonal Differences of Focus.

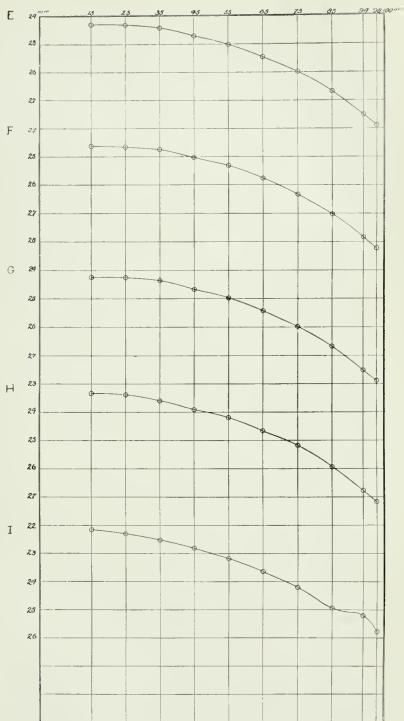


FIG. 41—Zonal Differences of Focus.

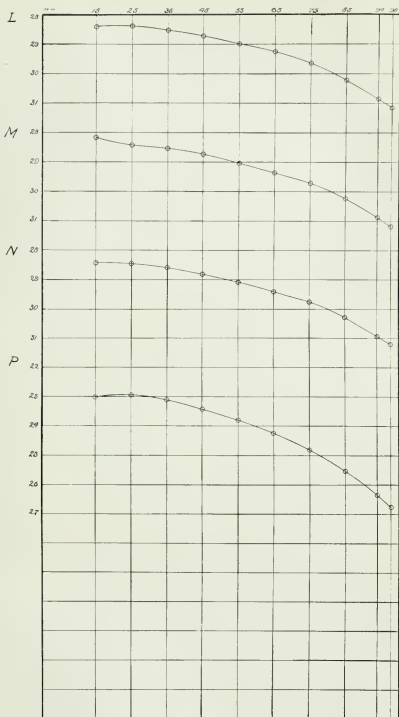


FIG. 42—Zonal Differences of Focus.

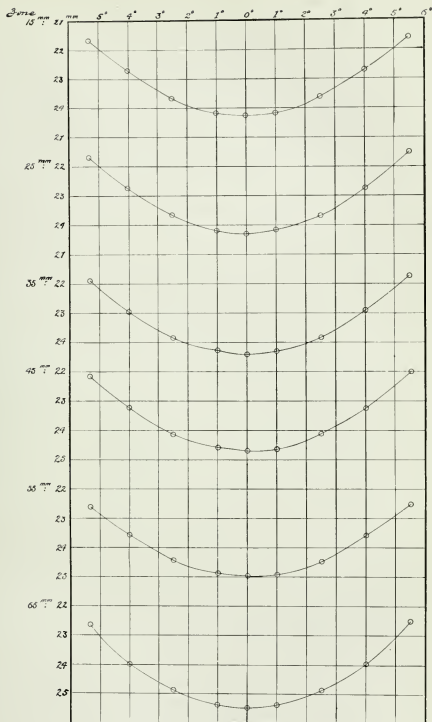


FIG. 43—Curvature of Field at different Zones.

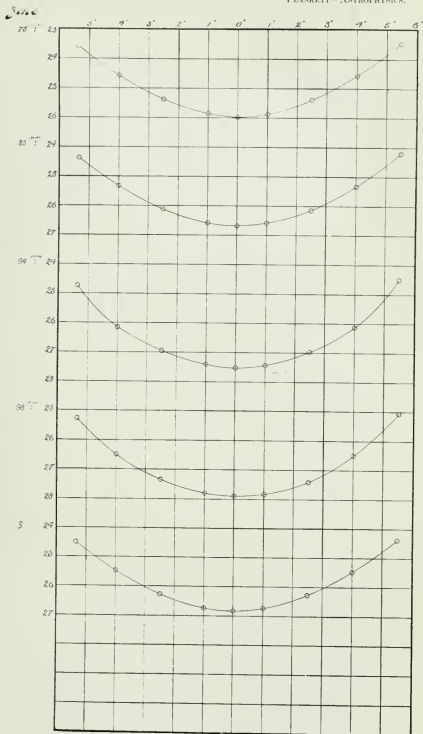


FIG. 44—Curvature of Field at different Zones.

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chromatic plates were substituted for the Seed Process plates and a yellow screen was placed just above the plate-holder to cut out the blue and violet light. The Cramer plate was used as it has a band of sensitiveness in the yellow-green light about λ 5650, as well as the band of sensitiveness to blue and violet light possessed by all plates. Three exposures were made within the focus and three without, their positions being:

Position L, 50' from centre to south.

" M, at centre.

" N, 50' from centre to north.

The exposure in each case was 5 minutes.

Comparing these with positions A to I, we find the aberration less by about 0.6 mm.

Position L showing negative aberration of 2.77 mm.

" M " " " 3.03 mm.

" N " " " 2.78 mm.

But it is not small enough to indicate any special adjustment of the lens surface to yellow light. The uniformity of the aberration is shown in L, M, N, Fig. 42. The astigmatism is similar to that shown by the Seed Process plate.

A uniform increase of about 3.5 mm. in the focus, as compared with the blue light, is due partly to refraction of the light in passing through the yellow screen. The screen being about 6 mm. thick, the refraction would lengthen the focus by about 2 mm., the refractive index of glass being about 1.57. The remaining 1.5 mm. is due to the difference in focus of blue and yellow light.

Combining the results of positions A to I (see table XIV.), we have the focus of each zone of the lens at nine different points extending from $5^{\circ}.3$ on one side of the centre to $5^{\circ}.5$ on the other side. Figs. 43 and 44 show the curvature as given from these foci, the coordinates being the diameter of the field in degrees and the zonal foci in millimetres. As in the case of the aberration these curves are very uniform, indicating a difference of about 2.5 mm. between the focus at the edge of the field and that at the centre.

Since the zonal foci of the lens vary so much from the centre to the edge no one position of focus is suitable to all the lenses. To obtain a uniform field and at the same time get as sharp a definition as possible, we must study the effect produced by the various zones when out of focus.

If we set, for example, the camera at the focus of the zone with radius of 65 mm., then other zones will be out of focus and there will be discs or circles of confusion about each image. The density and size of these circles depend on the extent to which the several zones are out of focus and also on the area of these zones. The diameter of these circles of confusion may be determined as follows:—

$$d = 2r \frac{(F - F_0)}{F_0}$$

where d = diameter of circle of confusion,

r = radius of zone,

F = focus of zone,

F_0 = focus at which the camera is set.

This determines for us the circles of confusion but it does not give us any idea of the effect on the image. A circle of confusion of 20" diameter and produced by a zone of 15 mm. radius would not be nearly so injurious to the image as one of the same diameter produced by a zone of 75 mm. radius. We see that simply determining the circles of confusion for the several zones will not give us the effect of the circles on the images, and so will not aid us in adjusting the camera to obtain the best images

possible under existing conditions. We must determine at what position of focus the lens is most efficient. The following formula by Hartmann gives a test for the efficiency of a lens at various foci:—

$$T = \frac{200000}{F_o^2} \cdot \frac{\sum r^2 (F - F_o)}{\sum r}$$

where T = efficiency of lens,

F = focus of zone,

F_o = focus at which the camera is set,

r = radius of zone.

(100000 is introduced simply to transfer the decimal point and so avoid exceedingly small numbers.) According to this test an objective is moderately good when T is greater than 1.5, good when T is between 0.5 and 1.5, and exceedingly good when T is less than 0.5. But as this criterion of efficiency refers to telescope objectives where the field of view and angular aperture are small, it is not an accurate test for photographic objectives of wide aperture.

Using the above formula, the best positions of focus at the several positions, A, B, C, etc., were obtained. Table XV. gives these foci, the diameters of the circles of confusion, and the efficiency of the lens. Curve *S*, Fig. 44, shows the combined results for the several positions A to I. From this curve it may be concluded that the best uniform field would be obtained by setting the camera at 25.75 mm. or 26.0 mm.

Testing for Chromatic Aberration.

Although the foregoing tests revealed a much greater spherical aberration than is consistent with the production of good negatives, objection was taken to the statement that this aberration was the cause of the observed defects in the images. Accordingly it was decided to test for chromatic aberration also.

The camera was detached from the telescope and mounted on a table, the source of light being an arc-lamp about 400 yards distant. The spectrograph was placed with the slit at the focus of the camera which was in line with the collimation tube. A cardboard disc was placed over the camera objective, the light entering through two oblong openings, 3 mm. by 8.5 mm., symmetrically placed on a common diameter.

Exposures were made with the slit first inside the camera focus and then outside, isochromatic plates being used to obtain the *D* lines. Images of the slits in the disc were thus obtained as produced by light of various wave-lengths. By measuring the distances between these images at twelve points and applying the Hartmann formula the focus of the camera was obtained for twelve different wave-lengths, as shown in the following table:—

| Wave-length. | Focus. |
|------------------------------------|-----------|
| λ 5893, <i>D</i> | 41.93 mm. |
| 5500 | 41.24 " |
| 5180 | 40.33 " |
| 4880 <i>H</i> β | 39.30 " |
| 4737 | 39.07 " |
| 4520 | 38.62 " |
| 4370 | 38.73 " |
| 4230 | 38.79 " |
| 4115 | 39.00 " |
| 4020 | 39.71 " |
| 3933, <i>K</i> | 39.98 " |
| 3780 | 40.88 " |

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Fig. 45 represents graphically the various foci and the chromatic aberration. The minimum focus is about $H\gamma$ and, while there is a range of 3.12 mm. in focus in the region between λ 5893 and λ 3780, there is less than 1 mm. range in the photographic region.

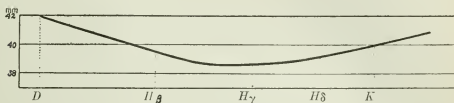


FIG. 45—Chromatic Aberration Curve.

Comparing this with the test for spherical aberration we have—

- (a) Minimum spherical aberration of - 3.6 mm.
- (b) Maximum chromatic aberration in photographic region of 1 mm.

Even if we allow for the chromatic aberration of 3 mm. at λ 5893, the light here is not rich enough in actinic properties to produce the observed halo. It seemed, therefore, unnecessary to continue the investigation *re* chromatic aberration.

Changing the Distance between the Components of the Outer Combination.

Prof. Hastings, of Yale University, who had been kept informed of the results of these tests, suggested that there might be sufficient internal reflection between the components of the objective to produce the observed halo and that this might be eliminated by increasing or decreasing the separation. Although we still felt that the defect was due to spherical aberration, this suggestion coming from the designer of the lens claimed our most careful attention and a series of tests were accordingly made. The original separation (one thickness of a postage stamp) was removed and new separations of various thicknesses used. Little blocks built up from bristol board were used until the best adjustment was obtained, after which hard rubber blocks were used.

The following table shows the tests and results:—

| Date. | Separation of Components. | Focus.* | Spherical Aberration. | Description of Images. |
|-------------|---------------------------|----------|-----------------------|--|
| 1908. | | | | |
| Jan. | 0.004 inches. | 47.5 mm. | - 3.6 mm. | Described in first part of appendix. |
| 1909. | | | | |
| Jan. 12.... | 0.012 " | 47.0 " | ..... | No change. |
| " 26.... | Tissue paper. | 47.5 " | ..... | " |
| Feb. 2.... | " | 47.5 " | ..... | $\frac{1}{2}$ " and $\frac{1}{4}$ " discs were placed on lens to cut off outer portion, but there was very little improvement. |
| " 25.... | 0.132 inches. | 26.5 " | + 2.4 mm. | Images about the same as originally. |
| Apr. 20.... | 0.070 " | 36.5 " | - 0.5 " | Images much improved. Halo greatly reduced. |
| May 25.... | 0.077 " | 36.0 " | - 0.3 " | Images much the same as with .070 separation. |

* Focus here refers to the scale on the camera tube.

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Curve α , Fig. 46, shows the aberration with a separation of 0.004 inches, curve β shows the aberration with a separation of 0.132 inches, and curve γ shows the aberration with a separation of 0.070 inches. Figure 47 shows cuts of the Pleiades taken with the different separations.

Examining the above table it is seen that increasing the separation, shortened the focus and changed the aberration. Coincident with the change in aberration there was a decided change in the star images. Aberrations of -3.6 mm. and $+2.4$ mm. were accompanied by a very marked halo, while with an aberration of -0.5 mm. the halo was negligible. Changing the separation to 0.070 inches has undoubtedly improved the objective as the field remained practically unchanged, and the halo was so small as to be neglected. But that this improvement has been effected by the removal of internal reflection does not seem at all probable. On the contrary, the above results seem to me to be but additional proof that the observed halo has been caused by spherical aberration, as was stated at the beginning of this appendix. It is not at all likely that the aberration and the halo would disappear simultaneously if the halo were caused by internal reflection.

Note.—Since the conclusion of the above work a communication has been received from the makers of the objective, stating that they also believe the defect to be due to spherical aberration and expressing their willingness to remove it without additional charge.

TABLE I.

ZONAL FOCI: POSITION A.

| Radius of Zone | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm. | 45 | 0.6450 | 0.6826 | 21.86 | | +0.20 |
| | 135 | 0.6333 | 0.6338 | 21.47 | 21.66 | -0.19 |
| 25 | 0 | 1.0432 | 1.1627 | 21.28 | | -0.37 |
| | 90 | 1.0746 | 1.1201 | 22.03 | 21.65 | +0.38 |
| 35 | 45 | 1.5131 | 1.5651 | 22.12 | | +0.23 |
| | 135 | 1.4948 | 1.6115 | 21.66 | 21.89 | -0.23 |
| 45 | 0 | 1.9259 | 2.0621 | 21.73 | | -0.44 |
| | 90 | 1.9921 | 1.9715 | 22.62 | 22.17 | +0.45 |
| 55 | 45 | 2.4355 | 2.3590 | 22.86 | | +0.26 |
| | 135 | 2.4166 | 2.4523 | 22.34 | 22.60 | -0.26 |
| 65 | 0 | 2.8795 | 2.8646 | 22.56 | | -0.06 |
| | 90 | 2.9851 | 2.7288 | 22.66 | 22.61 | +0.06 |
| 75 | 22.5 | 3.4195 | 3.1358 | 23.17 | | -0.15 |
| | 67.5 | 3.5344 | 3.0497 | 24.16 | | +0.54 |
| | 112.5 | 3.4794 | 3.1066 | 23.77 | | +0.15 |
| | 157.5 | 3.3935 | 3.2266 | 23.07 | 23.62 | -0.55 |
| 85 | 45 | 4.0807 | 3.3663 | 24.66 | | +0.29 |
| | 135 | 4.0195 | 3.4899 | 24.09 | 24.37 | -0.28 |
| 94 | 0 | 4.5666 | 3.7376 | 24.72 | | |
| | 90 | | | | 24.72 | |
| 98 | 22.5 | 4.8567 | 3.7280 | 25.46 | | +0.20 |
| | 67.5 | | | | | |
| | 112.5 | | | | | |
| | 157.5 | 4.8157 | 3.8320 | 25.06 | 25.26 | -0.20 |

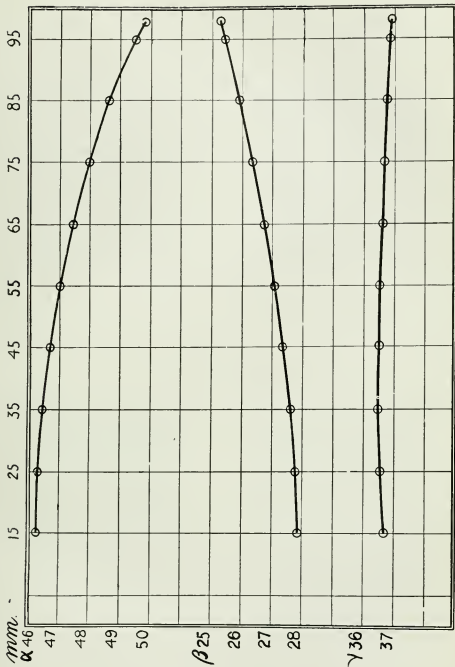
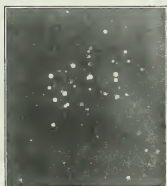


FIG. 46.—Zonal Difference of Focus.



Focus 47.0
Separation—Tissue Paper.
No Disc.



Focus 47.0
Separation—Tissue Paper.
 $\frac{1}{4}$ in. Disc.



Focus 26.5
Separation—0.132 inches.



Focus 36.5
Separation—0.070 inches.

FIG. 47—Star Photographs at Different Separations.

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TABLE II.

ZONAL FOCI: POSITION B.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm..... | 45 | 0.6694 | 0.6536 | 22.77 | | +0.08 |
| | 135 | 0.6625 | 0.6555 | 22.62 | 22.69 | -0.07 |
| 25..... | 0 | 1.1061 | 1.1020 | 22.54 | | -0.22 |
| | 90 | 1.1238 | 1.0793 | 22.90 | 22.76 | +0.23 |
| 35..... | 45 | 1.5766 | 1.5057 | 23.02 | | +0.10 |
| | 135 | 1.5740 | 1.5298 | 22.82 | 22.92 | -0.10 |
| 45..... | 0 | 2.0353 | 1.9518 | 22.97 | | -0.25 |
| | 90 | 2.0708 | 1.8979 | 23.48 | 23.22 | +0.26 |
| 55..... | 45 | 2.5308 | 2.2741 | 23.70 | | +0.14 |
| | 135 | 2.5368 | 2.3375 | 23.42 | 23.56 | -0.14 |
| 65..... | 0 | 3.0385 | 2.7147 | 23.77 | | -0.22 |
| | 90 | 3.0850 | 2.6503 | 24.21 | 23.99 | +0.22 |
| 75..... | 22.5 | 3.5797 | 2.9946 | 24.50 | | -0.07 |
| | 67.5 | 3.6489 | 2.9584 | 24.85 | | +0.28 |
| | 112.5 | 3.6175 | 2.9892 | 24.64 | | -0.07 |
| | 157.5 | 3.5760 | 3.0462 | 24.30 | 24.57 | -0.27 |
| 85..... | 45 | 4.2251 | 3.2505 | 25.43 | | +0.12 |
| | 135 | 4.2075 | 3.3061 | 25.20 | 25.31 | -0.11 |
| 94..... | 0 | 4.7707 | 3.5186 | 25.90 | | -0.28 |
| | 90 | 4.8840 | 3.4186 | 26.47 | 26.18 | +0.29 |
| 98..... | 22.5 | 5.0522 | 3.5470 | 26.44 | | -0.07 |
| | 67.5 | 5.0494 | 3.4591 | 26.71 | | +0.20 |
| | 112.5 | 5.0914 | 3.5125 | 26.63 | | +0.12 |
| | 157.5 | 5.0384 | 3.5950 | 26.26 | 26.51 | -0.25 |

TABLE III.

ZONAL FOCI: POSITION C.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm..... | 45 | 0.7003 | 0.6365 | 23.57 | | -0.04 |
| | 135 | 0.7023 | 0.6334 | 23.66 | 23.61 | +0.05 |
| 25..... | 0 | 1.1571 | 1.0546 | 23.54 | | -0.10 |
| | 90 | 1.1701 | 1.0470 | 23.75 | 23.64 | +0.11 |
| 35..... | 45 | 1.6446 | 1.4542 | 23.88 | | +0.05 |
| | 135 | 1.6394 | 1.4625 | 23.78 | 23.83 | -0.05 |
| 45..... | 0 | 2.1303 | 1.8615 | 24.02 | | -0.10 |
| | 90 | 2.1444 | 1.8404 | 24.22 | 24.12 | +0.10 |
| 55..... | 45 | 2.6238 | 2.2009 | 24.47 | | +0.05 |
| | 135 | 2.6415 | 2.2368 | 24.37 | 24.42 | -0.05 |
| 65..... | 0 | 3.1652 | 2.5791 | 24.80 | | -0.05 |
| | 90 | 3.1857 | 2.5686 | 24.91 | 24.85 | +0.06 |
| 75..... | 22.5 | 3.7187 | 2.8718 | 25.39 | | -0.01 |
| | 67.5 | 3.7533 | 2.8700 | 25.50 | | +0.10 |
| | 112.5 | 3.7401 | 2.8848 | 25.40 | | 0.00 |
| | 157.5 | 3.7206 | 2.8957 | 25.30 | 25.40 | -0.10 |
| 85..... | 45 | 4.3530 | 3.1223 | 26.20 | | -0.07 |
| | 135 | 4.3522 | 3.1638 | 26.06 | 26.13 | -0.07 |
| 94..... | 0 | 4.9560 | 3.3371 | 26.89 | | 0.00 |
| | 90 | 5.0673 | 3.3159 | 27.07 | 26.98 | +0.09 |
| 98..... | 22.5 | 5.2.15 | 3.3850 | 27.32 | | -0.04 |
| | 67.5 | 5.2741 | 3.3635 | 27.48 | | +0.12 |
| | 112.5 | 5.2528 | 3.3800 | 27.38 | | +0.02 |
| | 157.5 | 5.2405 | 3.4089 | 27.26 | 27.36 | -0.10 |

TABLE IV.

ZONAL FOCI: POSITION D.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15mm. | 45 | 0.7204 | 0.6208 | 24.17 | | -0.03 |
| | 135 | 0.7128 | 0.6106 | 24.24 | 24.20 | +0.04 |
| 25..... | 0 | 1.1883 | 1.0235 | 24.15 | | -0.02 |
| | 90 | 1.1963 | 1.0292 | 24.19 | 24.17 | +0.02 |
| 35..... | 45 | 1.6786 | 1.4273 | 24.32 | | +0.04 |
| | 135 | 1.6764 | 1.4340 | 24.25 | 24.28 | -0.03 |
| 45..... | 0 | 2.1796 | 1.8131 | 24.57 | | -0.02 |
| | 90 | 2.1843 | 1.8102 | 24.61 | 24.59 | +0.02 |
| 55..... | 45 | 2.6726 | 2.1618 | 24.88 | | -0.01 |
| | 135 | 2.7039 | 2.1805 | 24.91 | 24.89 | +0.02 |
| 65..... | 0 | 3.2398 | 2.5165 | 25.33 | | -0.02 |
| | 90 | 3.2503 | 2.5140 | 25.37 | 25.35 | +0.02 |
| 75..... | 22.5 | 3.7991 | 2.8022 | 25.90 | | +0.03 |
| | 67.5 | 3.8159 | 2.8151 | 25.90 | | +0.03 |
| | 112.5 | 3.8110 | 2.8295 | 25.83 | | -0.04 |
| | 157.5 | 3.8084 | 2.8193 | 25.86 | 25.87 | -0.01 |
| 85..... | 45 | 4.4340 | 3.0715 | 26.58 | | +0.01 |
| | 135 | 4.4404 | 3.0862 | 26.56 | 26.57 | -0.01 |
| 94..... | 0 | 5.0594 | 3.2538 | 27.39 | | -0.03 |
| | 90 | 5.0882 | 3.2528 | 27.45 | 27.42 | +0.03 |
| 98..... | 22.5 | 5.3326 | 3.2971 | 27.81 | | +0.01 |
| | 67.5 | 5.3435 | 3.3117 | 27.78 | | -0.02 |
| | 112.5 | 5.3394 | 3.3005 | 27.81 | | +0.01 |
| | 157.5 | 5.3453 | 3.3101 | 27.79 | 27.80 | -0.01 |

TABLE V.

ZONAL FOCI: POSITION E.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15mm. | 45 | 0.7243 | 0.6159 | 24.32 | | +0.03 |
| | 135 | 0.7189 | 0.6145 | 24.26 | 24.29 | -0.03 |
| 25..... | 0 | 1.1937 | 1.0189 | 24.28 | | -0.02 |
| | 90 | 1.2020 | 1.0215 | 24.33 | 24.30 | +0.03 |
| 35..... | 45 | 1.6884 | 1.4238 | 24.41 | | +0.01 |
| | 135 | 1.6907 | 1.4277 | 24.40 | 24.40 | 0.00 |
| 45..... | 0 | 2.1965 | 1.8049 | 24.70 | | 0.00 |
| | 90 | 2.1948 | 1.8038 | 24.70 | 24.70 | 0.00 |
| 55..... | 45 | 2.6918 | 2.1478 | 25.03 | | +0.02 |
| | 135 | 2.7202 | 2.1765 | 25.00 | 25.01 | -0.01 |
| 65..... | 0 | 3.2594 | 2.5023 | 25.46 | | 0.00 |
| | 90 | 3.2631 | 2.5050 | 25.46 | 25.46 | 0.00 |
| 75..... | 22.5 | 3.8166 | 2.7969 | 25.97 | | -0.01 |
| | 67.5 | 3.8365 | 2.8062 | 25.90 | | +0.01 |
| | 112.5 | 3.8381 | 2.8112 | 25.97 | | -0.01 |
| | 157.5 | 3.8347 | 2.8057 | 25.99 | 25.98 | +0.01 |
| 85..... | 45 | 4.4596 | 3.0610 | 26.68 | | 0.00 |
| | 135 | 4.4751 | 3.0733 | 26.68 | 26.68 | 0.00 |
| 94..... | 0 | 5.0876 | 3.2357 | 27.51 | | 0.00 |
| | 90 | 5.1113 | 3.2509 | 27.51 | 27.51 | 0.00 |
| 98..... | 22.5 | 5.3623 | 3.2966 | 27.87 | | -0.02 |
| | 67.5 | 5.3789 | 3.2991 | 27.89 | | 0.00 |
| | 112.5 | 5.3738 | 3.3000 | 27.88 | | -0.01 |
| | 157.5 | 5.3729 | 3.2913 | 27.91 | 27.89 | +0.02 |

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TABLE VI.
ZONAL FOCI: POSITION F.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm..... | 45 | 0.7306 | 0.6078 | 24.79 | ..... | +0.11 |
| | 135 | 0.7315 | 0.6130 | 24.48 | 24.59 | -0.11 |
| 25..... | 0 | 1.2242 | 1.0149 | 24.60 | ..... | -0.04 |
| | 90 | 1.2304 | 1.0127 | 24.68 | 24.64 | +0.04 |
| 35..... | 45 | 1.7274 | 1.4155 | 24.73 | ..... | +0.01 |
| | 135 | 1.7267 | 1.4160 | 24.72 | 24.72 | 0.00 |
| 45..... | 0 | 2.2431 | 1.7927 | 25.01 | ..... | -0.03 |
| | 90 | 2.2483 | 1.7875 | 25.07 | 25.04 | +0.03 |
| 55..... | 45 | 2.7507 | 2.1330 | 25.35 | ..... | +0.01 |
| | 135 | 2.7761 | 2.1567 | 25.33 | 25.34 | -0.01 |
| 65..... | 0 | 3.3281 | 2.4797 | 25.79 | ..... | -0.01 |
| | 90 | 3.3424 | 2.4826 | 25.82 | 25.80 | +0.02 |
| 75..... | 22.5 | 3.9033 | 2.7731 | 26.31 | ..... | -0.02 |
| | 67.5 | 3.9215 | 2.7751 | 26.35 | ..... | +0.02 |
| | 112.5 | 3.9230 | 2.7794 | 26.34 | ..... | +0.01 |
| | 157.5 | 3.9134 | 2.7826 | 26.30 | 26.33 | -0.03 |
| 85..... | 45 | 4.5513 | 3.0286 | 27.02 | ..... | 0.00 |
| | 135 | 4.5709 | 3.0376 | 27.03 | 27.02 | +0.01 |
| 94..... | 0 | 5.1894 | 3.2065 | 27.80 | ..... | -0.04 |
| | 90 | 5.2240 | 3.2063 | 27.88 | 27.84 | +0.04 |
| 98..... | 22.5 | 5.4615 | 3.2621 | 28.17 | ..... | -0.05 |
| | 67.5 | 5.4831 | 3.2539 | 28.24 | ..... | +0.02 |
| | 112.5 | 5.4846 | 3.2448 | 28.27 | ..... | +0.05 |
| | 157.5 | 5.4797 | 3.2630 | 28.21 | 28.22 | -0.01 |

TABLE VII.
ZONAL FOCI: POSITION G.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm..... | 45 | 0.7307 | 0.6203 | 24.29 | ..... | +0.04 |
| | 135 | 0.7256 | 0.6228 | 24.22 | 24.25 | -0.03 |
| 25..... | 0 | 1.1958 | 1.0336 | 24.14 | ..... | -0.10 |
| | 90 | 1.2129 | 1.0297 | 24.34 | 24.24 | +0.10 |
| 35..... | 45 | 1.7039 | 1.4425 | 24.37 | ..... | +0.01 |
| | 135 | 1.6995 | 1.4409 | 24.35 | 24.36 | -0.01 |
| 45..... | 0 | 2.2025 | 1.8339 | 24.55 | ..... | -0.10 |
| | 90 | 2.2164 | 1.8137 | 24.75 | 24.65 | +0.10 |
| 55..... | 45 | 2.7151 | 2.1758 | 25.00 | ..... | +0.03 |
| | 135 | 2.7339 | 2.1962 | 24.95 | 24.97 | -0.02 |
| 65..... | 0 | 3.2652 | 2.5402 | 25.31 | ..... | -0.12 |
| | 90 | 3.2975 | 2.5100 | 25.55 | 25.43 | +0.12 |
| 75..... | 22.5 | 3.8418 | 2.8348 | 25.89 | ..... | -0.07 |
| | 67.5 | 3.8710 | 2.8123 | 26.06 | ..... | +0.10 |
| | 112.5 | 3.8743 | 2.8281 | 26.01 | ..... | +0.05 |
| | 157.5 | 3.8565 | 2.8481 | 25.88 | 25.96 | -0.08 |
| 85..... | 45 | 4.5039 | 3.0808 | 26.72 | ..... | +0.04 |
| | 135 | 4.5072 | 3.1024 | 26.65 | 26.68 | -0.03 |
| 94..... | 0 | 5.1090 | 3.2893 | 27.38 | ..... | -0.13 |
| | 90 | 5.1685 | 3.2472 | 27.64 | 27.51 | +0.13 |
| 98..... | 22.5 | 5.3913 | 3.3340 | 27.80 | ..... | -0.08 |
| | 67.5 | 5.4340 | 3.3009 | 28.00 | ..... | +0.12 |
| | 112.5 | 5.4298 | 3.3093 | 27.96 | ..... | +0.08 |
| | 157.5 | 5.3990 | 3.3450 | 27.78 | 27.88 | -0.10 |

TABLE VIII.
ZONAL FOCI: POSITION H.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm | 45 | 0.7033 | 0.6505 | 23.38 | | +0.04 |
| | 135 | 0.7010 | 0.6528 | 23.30 | 23.34 | -0.04 |
| 25 | 0 | 1.1515 | 1.0961 | 23.05 | | -0.31 |
| | 90 | 1.1775 | 1.0610 | 23.67 | 23.36 | +0.31 |
| 35 | 45 | 1.6507 | 1.4920 | 23.64 | | +0.07 |
| | 135 | 1.6408 | 1.5005 | 23.50 | 23.57 | -0.07 |
| 45 | 0 | 2.1198 | 1.9152 | 23.64 | | -0.27 |
| | 90 | 2.1580 | 1.8560 | 24.19 | 23.91 | +0.28 |
| 55 | 45 | 2.6321 | 2.2501 | 24.26 | | +0.06 |
| | 135 | 2.6458 | 2.2870 | 24.14 | 24.20 | -0.06 |
| 65 | 0 | 3.1527 | 2.6581 | 24.41 | | -0.26 |
| | 90 | 3.2126 | 2.5830 | 24.94 | 24.67 | +0.27 |
| 75 | 22.5 | 3.7121 | 2.9610 | 25.03 | | -0.16 |
| | 67.5 | 3.7705 | 2.9036 | 25.42 | | +0.23 |
| | 112.5 | 3.7646 | 2.9178 | 25.35 | | +0.16 |
| | 157.5 | 3.7126 | 2.9823 | 24.95 | 25.19 | -0.24 |
| 85 | 45 | 4.3805 | 3.1964 | 26.01 | | +0.06 |
| | 135 | 4.3703 | 3.2255 | 25.89 | 25.95 | -0.06 |
| 94 | 0 | 4.9372 | 3.4590 | 26.46 | | -0.33 |
| | 90 | 5.0597 | 3.3340 | 27.13 | 26.79 | +0.34 |
| 98 | 22.5 | 5.2258 | 3.4928 | 26.97 | | -0.19 |
| | 67.5 | 5.3153 | 3.4031 | 27.43 | | +0.27 |
| | 112.5 | 5.3021 | 3.4164 | 27.37 | | +0.21 |
| | 157.5 | 5.2219 | 3.5158 | 26.89 | 27.16 | -0.27 |

TABLE IX.
ZONAL FOCI: POSITION I.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm | 45 | 0.6675 | 0.6798 | 22.29 | | +0.14 |
| | 135 | 0.6580 | 0.6869 | 22.02 | 22.15 | -0.13 |
| 25 | 0 | 1.0786 | 1.1508 | 21.77 | | -0.53 |
| | 90 | 1.1344 | 1.1005 | 22.84 | 22.30 | +0.51 |
| 35 | 45 | 1.5761 | 1.5551 | 22.65 | | +0.17 |
| | 135 | 1.5518 | 1.5765 | 22.32 | 22.48 | -0.16 |
| 45 | 0 | 1.9937 | 2.0341 | 22.27 | | -0.55 |
| | 90 | 2.0805 | 1.9245 | 23.38 | 22.82 | +0.56 |
| 55 | 45 | 2.5249 | 2.3421 | 23.34 | | +0.16 |
| | 135 | 2.5131 | 2.3998 | 23.02 | 23.18 | -0.16 |
| 65 | 0 | 2.9778 | 2.8323 | 23.06 | | -0.59 |
| | 90 | 3.1123 | 2.6623 | 24.25 | 23.65 | +0.60 |
| 75 | 22.5 | 3.5401 | 3.1225 | 23.91 | | -0.30 |
| | 67.5 | 3.6580 | 2.9877 | 24.77 | | +0.56 |
| | 112.5 | 3.6314 | 3.0360 | 24.51 | | +0.30 |
| | 157.5 | 3.5107 | 3.1646 | 23.67 | 24.21 | -0.54 |
| 85 | 45 | 4.2245 | 3.3275 | 25.17 | | +0.20 |
| | 135 | 4.1720 | 3.4060 | 24.77 | 24.97 | -0.20 |
| 94 | 0 | 4.7029 | 3.6958 | 25.20 | | -0.59 |
| | 90 | | | | 25.20 | +0.15 |
| 98 | 22.5 | 5.0145 | 3.6885 | 25.93 | | -0.15 |
| | 67.5 | | | | | +0.15 |
| | 112.5 | | | | | -0.15 |
| | 157.5 | 4.9712 | 3.7578 | 25.63 | 25.78 | -0.15 |

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TABLE X.

ZONAL FOCI: POSITION L.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm..... | 45 | 0·8580 | 0·5011 | 28·41 | | +0·03 |
| | 135 | 0·8478 | 0·4980 | 28·35 | 28·38 | -0·03 |
| 25..... | 0 | 1·4122 | 0·8305 | 28·34 | | -0·02 |
| | 90 | 1·4257 | 0·8345 | 28·38 | 28·36 | +0·02 |
| 35..... | 45 | 2·0004 | 1·1616 | 28·47 | | -0·04 |
| | 135 | 2·0018 | 1·1533 | 28·55 | 28·51 | +0·04 |
| 45..... | 0 | 2·5920 | 1·4647 | 28·75 | | +0·03 |
| | 90 | 2·5883 | 1·4712 | 28·69 | 28·72 | -0·03 |
| 55..... | 45 | 3·1567 | 1·7504 | 28·95 | | -0·05 |
| | 135 | 3·1968 | 1·7537 | 29·06 | 29·00 | +0·06 |
| 65..... | 0 | 3·8030 | 2·0479 | 29·25 | | -0·01 |
| | 90 | 3·8094 | 2·0455 | 29·28 | 29·26 | +0·02 |
| 75..... | 22·5 | 4·4142 | 2·2896 | 29·59 | | -0·08 |
| | 67·5 | 4·4469 | 2·2925 | 29·69 | | +0·02 |
| | 112·5 | 4·4305 | 2·2881 | 29·68 | | +0·01 |
| | 157·5 | 4·4525 | 2·2920 | 29·71 | 29·67 | +0·04 |
| 85..... | 45 | 5·1293 | 2·5171 | 30·19 | | -0·05 |
| | 135 | 5·1351 | 2·4940 | 30·29 | 30·24 | +0·05 |
| 94..... | 0 | 5·7941 | 2·6695 | 30·51 | | -0·04 |
| | 90 | 5·8120 | 2·6555 | 30·89 | 30·85 | +0·04 |
| 98..... | 22·5 | 6·0783 | 2·7200 | 31·09 | | -0·06 |
| | 67·5 | 6·0767 | 2·6950 | 31·17 | | +0·02 |
| | 112·5 | 6·0729 | 2·6946 | 31·17 | | +0·02 |
| | 157·5 | 6·0908 | 2·7050 | 31·16 | 31·15 | +0·01 |

TABLE XI.

ZONAL FOCI: POSITION M.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15 mm..... | 45 | 0·8617 | 0·5145 | 28·18 | | +0·02 |
| | 135 | 0·8519 | 0·5111 | 28·13 | 28·16 | -0·03 |
| 25..... | 0 | 1·4154 | 0·8238 | 28·44 | | -0·02 |
| | 90 | 1·4309 | 0·8295 | 28·49 | 28·46 | +0·03 |
| 35..... | 45 | 2·0053 | 1·1647 | 28·47 | | -0·06 |
| | 135 | 2·0039 | 1·1490 | 28·60 | 28·53 | +0·07 |
| 45..... | 0 | 2·5951 | 1·4685 | 28·74 | | -0·01 |
| | 90 | 2·5865 | 1·4601 | 28·76 | 28·75 | +0·01 |
| 55..... | 45 | 3·1740 | 1·7598 | 28·95 | | -0·08 |
| | 135 | 3·2043 | 1·7498 | 29·11 | 29·03 | +0·08 |
| 65..... | 0 | 3·8230 | 2·0360 | 29·36 | | 0·00 |
| | 90 | 3·8263 | 2·0381 | 29·36 | 29·36 | 0·00 |
| 75..... | 22·5 | 4·4467 | 2·2842 | 29·73 | | +0·03 |
| | 67·5 | 4·4591 | 2·2817 | 29·50 | | -0·11 |
| | 112·5 | 4·4541 | 2·2803 | 29·76 | | +0·06 |
| | 157·5 | 4·4353 | 2·2760 | 29·74 | 29·70 | +0·04 |
| 85..... | 45 | 5·1375 | 2·4931 | 30·30 | | +0·05 |
| | 135 | 5·1476 | 2·5197 | 30·21 | 30·25 | -0·04 |
| 94..... | 0 | 5·8073 | 2·6596 | 30·86 | | -0·01 |
| | 90 | 5·8189 | 2·6550 | 30·87 | 30·87 | 0·00 |
| 98..... | 22·5 | 6·0681 | 2·6932 | 31·21 | | +0·02 |
| | 67·5 | 6·1118 | 2·7059 | 31·19 | | 0·00 |
| | 112·5 | 6·0862 | 2·7090 | 31·14 | | -0·05 |
| | 157·5 | 6·0983 | 2·6950 | 31·21 | 31·19 | +0·02 |

TABLE XII.
ZONAL FOCI: POSITION N.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15mm | 45 | 0·8573 | 0·4968 | 28·49 | ..... | +0·07 |
| | 135 | 0·8578 | 0·5042 | 28·34 | 28·42 | -0·08 |
| 25..... | 0 | 1·4272 | 0·8332 | 28·41 | ..... | -0·05 |
| | 90 | 1·4232 | 0·8235 | 28·51 | 28·46 | +0·05 |
| 35..... | 45 | 2·0043 | 1·1518 | 28·58 | ..... | -0·02 |
| | 135 | 2·0138 | 1·1536 | 28·61 | 28·60 | +0·01 |
| 45..... | 0 | 2·6017 | 1·4565 | 28·85 | ..... | +0·04 |
| | 90 | 2·5934 | 1·4642 | 28·76 | 28·81 | -0·05 |
| 55..... | 45 | 3·1837 | 1·7478 | 29·05 | ..... | 0·00 |
| | 135 | 3·2112 | 1·7647 | 29·04 | 29·05 | -0·01 |
| 65..... | 0 | 3·8245 | 2·0250 | 29·42 | ..... | +0·01 |
| | 90 | 3·8307 | 2·0334 | 29·40 | 29·41 | -0·01 |
| 75..... | 22·5 | 4·4507 | 2·2902 | 29·71 | ..... | -0·04 |
| | 67·5 | 4·4635 | 2·2819 | 29·78 | ..... | +0·03 |
| | 112·5 | 4·4729 | 2·2797 | 29·81 | ..... | +0·06 |
| | 157·5 | 4·4321 | 2·2895 | 29·72 | 29·75 | -0·03 |
| 85..... | 45 | 5·1540 | 2·5082 | 30·27 | ..... | -0·02 |
| | 135 | 5·1560 | 2·4981 | 30·31 | 30·29 | +0·02 |
| 94..... | 0 | 5·8248 | 2·6439 | 30·95 | ..... | +0·03 |
| | 90 | 5·8086 | 2·6549 | 30·88 | 30·92 | -0·04 |
| 98..... | 22·5 | 6·0993 | 2·6965 | 31·20 | ..... | 0·00 |
| | 67·5 | 6·1101 | 2·7062 | 31·19 | ..... | -0·01 |
| | 112·5 | 6·1006 | 2·6947 | 31·21 | ..... | +0·01 |
| | 157·5 | 6·0933 | 2·6951 | 31·20 | 31·20 | 0·00 |

TABLE XIII.
ZONAL FOCI: POSITION R.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. | Astigmatism. |
|-----------------|--------|--------|--------|--------|-------|--------------|
| | ° | mm. | mm. | | | |
| 15mm | 45 | 0·6950 | 0·6533 | 23·20 | ..... | +0·18 |
| | 135 | 0·6707 | 0·6506 | 22·84 | 23·02 | -0·18 |
| 25..... | 0 | 1·1187 | 1·1000 | 22·69 | ..... | -0·23 |
| | 90 | 1·1413 | 1·0780 | 23·14 | 23·92 | +0·23 |
| 35..... | 45 | 1·6051 | 1·5079 | 23·20 | ..... | +0·08 |
| | 135 | 1·5904 | 1·5168 | 23·03 | 23·12 | -0·09 |
| 45..... | 0 | 2·0648 | 1·9508 | 23·14 | ..... | -0·30 |
| | 90 | 2·0668 | 1·8789 | 23·74 | 23·44 | +0·30 |
| 55..... | 45 | 2·5811 | 2·2793 | 23·90 | ..... | +0·12 |
| | 135 | 2·5683 | 2·3143 | 23·67 | 23·78 | -0·11 |
| 65..... | 0 | 3·0716 | 2·7009 | 23·94 | ..... | -0·28 |
| | 90 | 3·1285 | 2·6173 | 24·50 | 24·22 | +0·28 |
| 75..... | 22·5 | 3·6463 | 2·9964 | 24·70 | ..... | -0·09 |
| | 67·5 | 3·6927 | 2·9238 | 25·11 | ..... | +0·32 |
| | 112·5 | 3·6642 | 2·9616 | 24·89 | ..... | +0·10 |
| | 157·5 | 3·6180 | 3·0345 | 24·47 | 24·79 | -0·32 |
| 85..... | 45 | 4·2992 | 3·2352 | 25·68 | ..... | +0·15 |
| | 135 | 4·2542 | 3·2894 | 25·39 | 25·53 | -0·14 |
| 94..... | 0 | 4·8501 | 3·5156 | 26·09 | ..... | -0·30 |
| | 90 | 4·9240 | 3·3800 | 26·68 | 26·39 | +0·29 |
| 98..... | 22·5 | 5·1406 | 3·5317 | 26·67 | ..... | -0·12 |
| | 67·5 | 5·2145 | 3·4394 | 27·12 | | +0·33 |
| | 112·5 | 5·1649 | 3·4780 | 26·89 | | +0·10 |
| | 157·5 | 5·1125 | 3·5791 | 26·47 | 26·79 | -0·32 |

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TABLE XIV.

ZONAL FOCI.

| Radius of Zone. | Position. | | | | | |
|-----------------|-----------|-------|-------|-------|-------|-------|
| | A | B | C | D | E | F |
| 15 mm..... | 21.66 | 22.69 | 23.61 | 24.20 | 24.29 | 24.59 |
| 25..... | 21.65 | 22.76 | 23.64 | 24.17 | 24.30 | 24.64 |
| 35..... | 21.89 | 22.92 | 23.83 | 24.28 | 24.40 | 24.72 |
| 45..... | 22.17 | 23.22 | 24.12 | 24.59 | 24.70 | 25.04 |
| 55..... | 22.60 | 23.56 | 24.42 | 24.89 | 25.01 | 25.34 |
| 65..... | 22.61 | 23.99 | 24.85 | 25.35 | 25.46 | 25.80 |
| 75..... | 23.62 | 24.57 | 25.46 | 25.87 | 25.98 | 26.33 |
| 85..... | 24.47 | 25.31 | 26.13 | 26.57 | 26.68 | 27.02 |
| 94..... | 24.72 | 26.18 | 26.98 | 27.42 | 27.51 | 27.84 |
| 98..... | 25.26 | 26.51 | 27.36 | 27.80 | 27.89 | 28.22 |
| | G | H | I | L | M | N |
| 15 mm..... | 24.25 | 23.34 | 22.15 | 28.38 | 28.16 | 28.42 |
| 25..... | 24.24 | 23.36 | 22.30 | 28.36 | 28.46 | 28.46 |
| 35..... | 24.36 | 23.57 | 22.48 | 28.51 | 28.53 | 28.60 |
| 45..... | 24.65 | 23.91 | 22.82 | 28.72 | 28.75 | 28.81 |
| 55..... | 24.97 | 24.20 | 23.18 | 29.00 | 29.03 | 29.05 |
| 65..... | 25.43 | 24.67 | 23.65 | 29.26 | 29.36 | 29.41 |
| 75..... | 25.96 | 25.19 | 24.21 | 29.67 | 29.70 | 29.75 |
| 85..... | 26.68 | 25.95 | 24.97 | 30.24 | 30.25 | 30.29 |
| 94..... | 27.51 | 26.79 | 25.20 | 30.85 | 30.87 | 30.92 |
| 98..... | 27.88 | 27.16 | 25.78 | 31.15 | 31.19 | 31.20 |

TABLE XV.

| Plate. | Best Focus. | Confusion Circle. | Efficiency. |
|--------|-------------|-------------------|-------------|
| A..... | 24.5 | 44.2 | 11.46 |
| B..... | 25.5 | 38.5 | 13.43 |
| C..... | 26.25 | 39.2 | 13.11 |
| D..... | 26.75 | 37.9 | 13.01 |
| E..... | 26.8 | 38.5 | 12.77 |
| F..... | 27.00 | 43.1 | 12.56 |
| G..... | 26.7 | 41.7 | 12.71 |
| H..... | 26.00 | 41.00 | 13.08 |
| I..... | 25.00 | 36.00 | 10.52 |
| L..... | 30.20 | 33.3 | 9.64 |
| M..... | 30.25 | 33.0 | 9.47 |
| N..... | 30.30 | 31.7 | 9.38 |

TABLE XVI.

ZONAL TEST.

Settings 6·5 & 51·5; Separation 0·132 inches.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. |
|-----------------|--------|--------|--------|--------|-------|
| | ° | mm. | mm. | | |
| 15 mm. | 45 | 0·6422 | 0·7178 | 21·25 | |
| | 135 | 0·6389 | 0·7130 | 21·27 | 21·26 |
| 25..... | 0 | 1·0595 | 1·1848 | 21·24 | |
| | 90 | 1·0605 | 1·1895 | 21·21 | 21·22 |
| 35..... | 45 | 1·4779 | 1·6885 | 21·00 | |
| | 135 | 1·4683 | 1·6827 | 20·97 | 20·98 |
| 45..... | 0 | 1·8743 | 2·1880 | 20·76 | |
| | 90 | 1·8729 | 2·1754 | 20·82 | 20·79 |
| 55..... | 45 | 2·2487 | 2·6728 | 20·56 | |
| | 135 | 2·2606 | 2·6841 | 20·57 | 20·56 |
| 65..... | 0 | 2·6086 | 3·2090 | 20·18 | |
| | 90 | 2·6180 | 3·2597 | 19·91 | 20·04 |
| 75..... | 22·5 | 2·9475 | 3·7395 | 19·83 | |
| | 67·5 | 2·9587 | 3·7468 | 19·86 | |
| | 112·5 | 2·9633 | 3·7468 | 19·87 | |
| | 157·5 | 2·9505 | 3·7495 | 19·82 | 19·84 |
| 85..... | 45 | 3·2795 | 4·3160 | 19·43 | |
| | 135 | 3·2858 | 4·3213 | 19·44 | 19·43 |
| 94..... | 0 | 3·5285 | 4·8575 | 18·93 | |
| | 90 | 3·5398 | 4·8555 | 18·97 | 18·95 |
| 98..... | 22·5 | 3·6505 | 5·0663 | 18·78 | |
| | 67·5 | 3·6643 | 5·0935 | 18·83 | |
| | 112·5 | 3·6723 | 5·0755 | 18·89 | |
| | 157·5 | 3·6506 | 5·0691 | 18·86 | 18·84 |

TABLE XVII.

ZONAL TEST.

Settings 16·5 & 61·5; Separation 0·070 inches.

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. |
|-----------------|--------|--------|--------|--------|-------|
| | ° | mm. | mm. | | |
| 15 mm. | 45 | 0·6014 | 0·7332 | 20·23 | |
| | 135 | 0·5953 | 0·7372 | 20·10 | 20·16 |
| 25..... | 0 | 0·9944 | 1·2348 | 20·07 | |
| | 90 | 0·9931 | 1·2375 | 20·03 | 20·05 |
| 35..... | 45 | 1·3921 | 1·7460 | 19·96 | |
| | 135 | 1·3905 | 1·7501 | 19·93 | 19·95 |
| 45..... | 0 | 1·7970 | 2·2300 | 20·08 | |
| | 90 | 1·7882 | 2·2236 | 20·06 | 20·07 |
| 55..... | 45 | 2·1784 | 2·7251 | 19·99 | |
| | 135 | 2·1720 | 2·7159 | 19·99 | 19·99 |
| 65..... | 0 | 2·5940 | 3·2068 | 20·12 | |
| | 90 | 2·5899 | 3·2110 | 20·09 | 20·11 |
| 75..... | 22·5 | 2·9884 | 3·6893 | 20·14 | |
| | 67·5 | 2·9855 | 3·6896 | 20·13 | |
| | 112·5 | 2·9914 | 3·6926 | 20·14 | |
| | 157·5 | 2·9805 | 3·6919 | 20·10 | 20·13 |
| 85..... | 45 | 3·4127 | 4·1765 | 20·24 | |
| | 135 | 3·4084 | 4·1754 | 20·22 | 20·23 |
| 94..... | 0 | 3·7945 | 4·5940 | 20·36 | |
| | 90 | 3·7910 | 4·6020 | 20·33 | 20·35 |
| 98..... | 22·5 | 3·9770 | 4·7611 | 20·48 | |
| | 67·5 | 3·9740 | 4·7611 | 20·47 | |
| | 112·5 | 3·9755 | 4·7650 | 20·47 | |
| | 157·5 | 3·9755 | 4·7735 | 20·45 | 20·47 |

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TABLE XVIII.

SETTINGS 16.5 AND 61.5; 0.077 SEPARATION

| Radius of Zone. | ϕ | d_1 | d_2 | Focus. | Mean. |
|-----------------|--------|--------|--------|--------|-------|
| | ° | mm. | mm. | | |
| 15..... | 45 | 0.5717 | 0.7561 | 19.38 | |
| | 135 | 0.5830 | 0.7540 | | 19.38 |
| 25..... | 0 | 0.9550 | 1.2645 | 19.36 | |
| | 90 | 0.9549 | 1.2662 | 19.35 | 19.36 |
| 35..... | 45 | 1.3335 | 1.7745 | 19.31 | |
| | 135 | 1.3365 | 1.7831 | 19.28 | 19.30 |
| 45..... | 0 | 1.7208 | 2.2832 | 19.34 | |
| | 90 | 1.7228 | 2.2750 | 19.39 | 19.37 |
| 55..... | 45 | 2.0918 | 2.7819 | 19.31 | |
| | 135 | 2.0909 | 2.7681 | 19.36 | 19.34 |
| 65..... | 0 | 2.4909 | 3.2762 | 19.44 | |
| | 90 | 2.4915 | 3.2844 | 19.41 | 19.43 |
| 75..... | 22.5 | 2.8593 | 3.7774 | 19.39 | |
| | 67.5 | 2.8637 | 3.7804 | 19.39 | |
| | 112.5 | 2.8707 | 3.7829 | 19.42 | |
| | 157.5 | 2.8585 | 3.7694 | 19.41 | 19.40 |
| 85..... | 45 | 3.2567 | 4.2874 | 19.43 | |
| | 135 | 3.2742 | 4.2702 | 19.53 | 19.48 |
| 94..... | 0 | 3.6387 | 4.7187 | 19.59 | |
| | 90 | 3.6456 | 4.7240 | 19.60 | 19.60 |
| 98..... | 22.5 | 3.7929 | 4.9030 | 19.63 | |
| | 67.5 | 3.7942 | 4.9054 | 19.63 | |
| | 112.5 | 3.8191 | 4.8918 | | |
| | 157.5 | 3.7988 | 4.8958 | 19.66 | 19.64 |

APPENDIX E.

OBSERVING RECORDS AND DETAILED MEASURES OF β ORIONIS, α AQUILÆ, ϵ HERCULIS, γ BOÖTIS, α CORONÆ BOREALIS AND δ AQUILÆ. β ORIONIS.
RECORD OF SPECTROGRAMS.P. — Plaskett.
H. — Harper.
C. — Cannon.
P. — Parker.

| Star. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure, G. M. T. | Duration. | Hour Angle at end. | TEMPERATURE CENTIGRADE. | | | | Slit Width. | Seeing. | Observer. | Remarks. |
|-----------------|------------------|---------|--------|---------|------------------------------|-----------|--------------------|-------------------------|-------|------------|------|-------------|---------|-----------|----------|
| | | | | | | | | Room. | | Prism Box. | | | | | |
| | | | | | | | | Begin. | End. | Begin. | End. | | | | |
| β Orionis | 1241a | HL | Sed 27 | Jan. 26 | h. m. | m. | h. m. | - 7.0 | ..... | 6.9 | 6.9 | .001 | Poor | P | |
| " | 1241b | " | " | " | 15 03 | 2½ | 52 W. | ..... | ..... | " | " | " | " | P | |
| " | 1241c | " | " | " | 15 05 | " | 55 " | ..... | ..... | " | " | " | " | P | |
| " | 1241d | " | " | " | 15 07½ | " | 57½ " | ..... | ..... | " | " | " | " | P | |
| " | 1242a | " | " | " | 15 12½ | " | 1 02½ " | ..... | ..... | " | " | " | " | P | |
| " | 1242b | " | " | " | 15 15 | " | 1 05 " | ..... | ..... | " | " | " | " | P | |
| " | 1242c | " | " | " | 15 17½ | " | 1 07½ " | ..... | ..... | " | " | " | " | P | |
| " | 1243a | " | " | " | 15 25 | 1½ | 1 16 " | ..... | ..... | " | " | .0015 | " | P | |
| " | 1243b | " | " | " | 15 27 | " | 1 18 " | ..... | ..... | " | " | " | " | P | |
| " | 1243c | " | " | " | 15 29 | " | 1 20 " | ..... | ..... | " | " | " | " | P | |
| " | 1244a | " | " | " | 15 45 | 1½ | 1 36 " | ..... | ..... | " | " | " | " | P | |
| " | 1244b | " | " | " | 15 47 | " | 1 38 " | ..... | ..... | " | " | " | " | P | |
| " | 1244c | " | " | " | 15 49 | " | 1 40 " | ..... | ..... | " | " | " | " | P | |
| " | 1245a | " | " | " | 15 52 | 5½ | 1 43 " | ..... | ..... | " | " | .002 | " | P | |
| " | 1245b | " | " | " | 15 53 | " | 1 44 " | ..... | ..... | " | " | " | " | P | |
| " | 1245c | " | " | " | 15 54 | " | 1 45 " | ..... | ..... | " | " | " | " | P | |
| " | 1247a | " | " | " | 16 16 | 40 | 2 05 " | ..... | ..... | " | " | .003 | " | P | |
| " | 1247b | " | " | " | 16 17 | " | 2 06 " | ..... | ..... | " | " | " | " | P | |
| " | 1247c | " | " | " | 16 18 | " | 2 07 " | ..... | ..... | " | " | " | " | P | |
| " | 1248a | " | " | " | 16 26 | " | 2 15 " | ..... | ..... | " | " | " | " | P | |
| " | 1248b | " | " | " | 16 27 | " | 2 16 " | ..... | ..... | " | " | " | " | P | |
| " | 1248c | " | " | " | 16 28 | " | 2 17 " | ..... | ..... | " | " | " | " | P | |
| " | 1249a | " | " | " | 16 35 | 1 | 2 23 " | ..... | ..... | " | " | .002 | " | P | |
| " | 1249b | " | " | " | 16 37 | " | 2 25 " | ..... | ..... | " | " | " | " | P | |
| " | 1249c | " | " | " | 16 39 | " | 2 27 " | ..... | ..... | " | " | " | " | P | |
| " | 1285a | HL | " | " | 15 46 | 5 | 2 00 " | 13.0 | 6.5 | 16.0 | 16.0 | .001 | Good | P | |
| " | 1285b | " | " | " | 15 51 | " | 2 05 " | " | " | " | " | " | " | P | |

[illegible]

9-10 EDWARD VII., A. 1910

β ORIONIS.
RECORD OF SPECTROGRAMS—Continued.

P.—Plaskett.
H.—Harper.
C.—Cannon.
P.—Parker.

| Star. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure G. M. T. | Duration. | Hour Angle at end. | TEMPERATURE CENTIGRADE. | | | | Slit Width. | Seeing. | Observer. | Remarks. |
|---------------------|------------------|---------|------------|---------------------|--------------------------------|-----------|-----------------------|----------------------------|------|-----------------|------|----------------|----------|-----------|----------|
| | | | | | | | | Room. | | Prism Box. | | | | | |
| | | | | | h. m. | m. | h. m. | Begin- ning. | End. | Begin- ning. | End. | | | | |
| β Orionis.... | 1937 | III L | Seed 27... | 1908. Oct. 13... | 22 19 | 30 | 1 50 W. | 7-6 | 7-6 | 11-6 | 11-6 | .0016 | Fair.... | P | |
| " | 1938 | " | " | " | 22 47 | 25 | 2 15 " | " | 7-5 | " | " | " | " | P | |
| " | 1978 | " | " | Nov. 21... | 18 24 | 18 | 0 25 " | 2-7 | 2-6 | 4-9 | 4-9 | .0015 | " | P | |
| " | 1979 | " | " | " | 21 18 | 43 | 0 45 " | 2-6 | 1-5 | " | " | " | " | P | |
| " | 1980 | " | " | " | 21 19 | 45 | 22 1 10 " | 1-4 | 0-3 | " | 4-8 | " | " | P | |
| " | 1981 | " | " | " | 21 19 | 33 | 30 1 40 " | 0-3 | 1-5 | 4-8 | " | " | " | P | |
| " | 1984 | " | " | " | 28 16 | 65 | 20 1 30 E. | 5-2 | 5-0 | 6-7 | 6-7 | .0016 | " | P | |
| " | 1985 | " | " | " | 28 16 | 34 | 22 1 00 " | 5-0 | 5-5 | " | " | " | " | P | |
| " | 1986 | " | " | " | 28 17 | 08 | 15 0 10 " | 5-5 | " | " | " | " | " | P | |
| " | 1987 | " | " | Dec. 1... | 17 53 | 27 | 0 35 W. | 3-8 | 4-0 | 1-8 | " | " | Good.... | P | |
| " | 1988 | " | " | " | 1 18 | 18 | 16 1 00 " | 4-0 | 4-1 | " | " | " | " | P | |
| " | 1989 | " | " | " | 1 18 | 36 | 16 1 18 " | 4-1 | 4-2 | " | " | " | " | P | |
| " | 1990 | " | " | " | 1 18 | 52 | 15 1 34 " | 4-2 | 4-5 | " | " | " | " | P | |
| " | 2003 | " | " | " | 5 16 | 10 | 1 00 E. | 16-0 | 16-5 | 7-9 | 7-9 | " | Fair.... | P | |
| " | 2004 | " | " | " | 5 16 | 22 | 10 0 48 " | " | " | " | " | .0016 | " | P | |
| " | 2005 | " | " | " | 5 16 | 38 | 13 0 32 " | " | " | " | " | " | " | P | |
| " | 2006 | " | " | " | 5 16 | 53 | 13 0 15 " | " | 17-8 | " | 7-9 | " | Poor.... | P | |
| " | 2054 | II L | " | " | 21 15 | 24 | 3 0 24 " | 11-2 | 11-2 | 1-6 | 1-6 | .0015 | Good.... | P | |
| " | 2055 | " | " | " | 21 15 | 29 | 2 0 20 " | " | " | " | " | " | " | P | |
| " | 2057 | " | " | " | 21 16 | 54 | 2 0 45 W. | 12-4 | 12-4 | 1-9 | 1-9 | " | " | P | |
| " | 2058 | " | " | " | 21 17 | 00 | 2 0 51 " | " | " | " | " | " | " | P | |
| " | 2059 | III L | " | " | 22 17 | 38 | 10 1 20 " | 18-5 | " | 13-0 | " | .0016 | " | P | |
| " | 2065 | " | " | " | 22 17 | 52 | 9 1 32 " | " | " | " | " | " | " | P | |
| " | 2066 | " | " | " | 22 18 | 02 | 8 1 43 " | " | " | " | " | " | " | P | |
| " | 2067 | " | " | " | 22 18 | 14 | 8 2 10 " | " | 19-0 | " | 13-0 | " | " | P | |
| " | 2068 | " | " | " | 23 14 | 01 | 14 1 55 E. | 14-5 | 14-5 | 7-5 | 7-5 | " | " | H | |
| " | 2070 | " | " | " | 23 14 | 41 | 44 1 00 " | 16-0 | 15-0 | 7-8 | 7-9 | " | Poor.... | II. P. | |
| " | 2071 | " | " | " | 23 15 | 08 | 8 0 50 " | " | " | 7-9 | " | " | " | P | |
| " | 2072 | " | " | " | 23 15 | 19 | 8 0 40 " | " | " | " | " | " | " | P | |
| " | 2073 | " | " | " | 23 15 | 49 | 8 0 00 " | 9-8 | " | 4-1 | " | " | Steady. | P | |
| " | 2075 | " | " | " | 26 15 | 49 | 8 0 40 " | " | " | " | " | " | " | P | |

Drifting.

β ORIONIS.
RECORD OF SPECTROGRAMS.—Continued.

P.—Plaskett.
H.—Harper.
C.—Cannon.
P.—Parker.

| Star. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure, G. M. T. | Duration. | Hour Angle at End. | TEMPERATURE CENTIGRADE. | | | | Slit Width. | Seeing. | Observer. | Remarks. |
|---------------------|------------------|---------|---------|----------------|------------------------------|-----------|--------------------|-------------------------|-------|-----------------|--------|-----------------|---------|-----------|----------|
| | | | | | | | | Room. | | Prism Box. | | | | | |
| | | | | | | | | Begin- ning. | End. | Begin- ning. | End. | | | | |
| β Orionis.... | 2165 | IL | Seed 27 | 1902, Jan. 18. | h. m. | m. | h. m. | | | | | | | | |
| " | 2166 | " | " | " 18. | 13 10 | 2 | 1 11 E. | | | | | 0.015 | | P | |
| " | 2167 | " | " | " 18. | 13 14 | 2 | 1 08 " | | | | - 13.8 | " | | P | |
| " | 2177 | " | " | " 26. | 10 36 | 3 | 3 10 " | | 1.0 | + 1.8 | | 0.013 Good. | | P | |
| " | 2178 | " | " | " 26. | 10 51 | 2 | 2 55 " | | | | | " | | P | |
| " | 2179 | " | " | " 26. | 10 56 | 2 | 2 50 " | | | | | " | | P | |
| " | 2180 | " | " | " 26. | 11 01 | 3 | 2 45 " | | | | | " | | P | |
| " | 2181 | " | " | " 26. | 11 11 | 2 | 2 35 " | | | | | " | | P | |
| " | 2182 | " | " | " 26. | 11 16 | 3 | 2 30 " | | | | | " | | P | |
| " | 2183 | " | " | " 26. | 11 21 | 2 | 2 25 " | | | | + 1.8 | " | | P | |
| " | 2184 | " | " | " 28. | 11 21 | 2 | 2 20 " | | - 8.3 | - 6.9 | | " | | P | |
| " | 2185 | " | " | " 28. | 11 25 | 2 | 2 16 " | | | | | " | | P | |
| " | 2186 | " | " | " 28. | 11 29 | 2 | 2 12 " | | | | | " | | P | |
| " | 2187 | " | " | " 28. | 11 41 | 2 | 2 00 " | | | | | " | | P | |
| " | 2188 | " | " | " 28. | 11 44 | 2 | 1 57 " | | | | | " | | P | |
| " | 2189 | " | " | " 28. | 11 47 | 2 | 1 55 " | | - 9.0 | - 6.9 | | " | | P | |
| " | 2195 | " | " | " 29. | 12 53 | 2 | 0 40 " | | - 6.4 | 0.0 | | " | | C | |
| " | 2196 | " | " | " 29. | 12 57 | 3 | 0 38 " | | | | | " | | C | |
| " | 2197 | " | " | " 29. | 13 01 | 2 | 0 34 " | | | | | " | | C | |
| " | 2198 | " | " | " 29. | 13 05 | 3 | 0 30 " | | - 6.4 | 0.0 | | " | Fair. | C | |
| " | 2201 | " | " | " 30. | 12 29 | 2 | 1 00 " | | | | | " | | P | |
| " | 2202 | " | " | " 30. | 12 41 | 2 | 0 48 " | | | | | " | | P | |
| " | 2203 | " | " | " 30. | 12 45 | 2 | 0 45 " | | | | | " | | P | |
| " | 2204 | " | " | " 30. | 12 48 | 2 | 0 42 " | | - 3.8 | | - 2.6 | " | | P | |
| " | 2205 | III | " | " 30. | 15 47 | 14 | 2 20 W. | | - 6.0 | - 2.7 | | 0.016 Unsteady. | | P | |
| " | 2206 | " | " | " 30. | 16 04 | 16 | 2 37 " | | | | | " | | P | |
| " | 2207 | " | " | " 30. | 16 24 | 19 | 3 00 " | | - 6.6 | - 2.8 | | " | | P | |
| " | 2211 | IL | " | " 31. | 17 16 | 3 | 3 32 " | | | | | " | | H | |
| " | 2212 | " | " | " 31. | 17 20 | 3 | 3 36 " | -19.0 | | - 6.0 | | " | | H | |
| " | 2213 | " | " | " 31. | 17 24 | 5 | 3 40 " | -19.0 | | | | " | | H | |
| " | 2214 | " | " | " 31. | 17 29 | 5 | 3 45 " | -19.0 | | | - 6.0 | " | | H | |

β ORIONIS.
RECORD OF SPECTROGRAMS.—Continued.

P.—Plaskett.
H.—Harper.
C.—Cannon.
P.—Parker.

| Star. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure, G. M. T. | Duration. | Hour Angle at End. | TEMPERATURE CENTIGRADE. | | | | Slit Width. | Seeing. | Observer. | Remarks. |
|-----------|------------------|---------|----------|----------------|------------------------------|-----------|--------------------|-------------------------|-------|-------------|-------|-------------|---------|-----------|----------|
| | | | | | | | | Room. | | Prism Box. | | | | | |
| | | | | | h. m. | m. | h. m. | Begin-ning. | End. | Begin-ning. | End. | | | | |
| β Orionis | 2314 | IHL | Seed 27. | 1909, Feb. 28. | 12 27 | 7 | 50 W. | ..... | ..... | ..... | ..... | .0015 | Good | P | |
| | 2315 | " | " | " 28. | 12 39 | 12 | 1 02 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2316 | " | " | " 28. | 12 50 | 8 | 1 15 " | ..... | ..... | ..... | 1.3 | " | " | P | |
| | 2317 | " | " | Mar. 2. | 11 05 | 10 | 22 E. | 0.3 | 8.4 | 3.6 | ..... | .0016 | " | P | |
| | 2318 | " | " | " 2. | 11 19 | 8 | 8 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2319 | " | " | " 2. | 11 29 | 8 | 2 W. | ..... | ..... | ..... | ..... | " | " | P | |
| | 2320 | " | " | " 2. | 11 39 | 8 | 10 " | 1.0 | ..... | 3.6 | ..... | .0015 | " | P | |
| | 2321 | " | " | " 2. | 11 49 | 8 | 10 " | 2.8 | ..... | 7.2 | ..... | " | " | P | |
| | 2322 | " | " | " 13. | 12 12 | 8 | 1 28 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2323 | " | " | " 13. | 12 24 | 8 | 1 40 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2324 | " | " | " 13. | 12 36 | 8 | 1 52 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2325 | " | " | " 13. | 12 46 | 7 | 2 02 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2326 | " | " | " 13. | 12 57 | 6 | 2 10 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2327 | " | " | " 15. | 11 45 | 10 | 1 10 " | -0.4 | 2.1 | 2.0 | 7.0 | " | " | P | |
| | 2328 | " | " | " 15. | 11 56 | 7 | 1 21 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2329 | " | " | " 15. | 12 05 | 6 | 1 30 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2330 | " | " | " 15. | 12 13 | 6 | 1 35 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2331 | " | " | " 15. | 12 21 | 6 | 1 40 " | ..... | ..... | ..... | ..... | " | " | P | |
| | 2332 | " | " | " 15. | 12 21 | 9 | 1 40 " | -0.4 | -1.2 | 3.8 | +1.9 | " | " | P | |
| | 2333 | " | " | " 18. | 11 42 | 7 | 1 30 " | ..... | ..... | ..... | ..... | " | " | P | |
| 2334 | " | " | " 18. | 11 52 | 7 | 1 30 " | ..... | ..... | ..... | ..... | " | " | P | | |
| 2335 | " | " | " 18. | 12 02 | 8 | 1 40 " | ..... | ..... | ..... | ..... | " | " | P | | |
| 2336 | " | " | " 18. | 12 12 | 8 | 1 50 " | ..... | ..... | ..... | ..... | " | " | P | | |
| 2337 | " | " | " 20. | 12 16 | 7 | 1 50 " | 11.0 | 0.5 | 7.2 | 3.7 | " | Fair | P | | |
| 2338 | " | " | " 20. | 12 26 | 7 | 1 10 " | ..... | ..... | ..... | ..... | " | " | P | | |
| 2339 | " | " | " 20. | 12 38 | 10 | 1 22 " | ..... | ..... | ..... | ..... | " | " | P | | |
| 2340 | " | " | " 20. | 12 48 | 7 | 1 30 " | ..... | ..... | ..... | ..... | " | " | P | | |
| 2341 | " | " | " 20. | 12 58 | 7 | 1 40 " | ..... | ..... | ..... | ..... | " | " | P | | |
| 2342 | " | " | " 21. | 13 38 | 8 | 3 25 " | -1.8 | 0.5 | 4.0 | 7.0 | " | " | P | | |
| 2343 | " | " | " 21. | 13 48 | 9 | 3 35 " | | | | | " | " | P | | |
| 2344 | " | " | " 21. | 14 00 | 11 | 3 47 " | | | | | " | " | P | | |
| 2345 | " | " | " 21. | 14 14 | 12 | 4 02 " | | | -3.8 | | 3.9 | " | " | P | |

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| | | | | | | | | | |
|------|----|----|----|---|----|-------|-------|------|---|
| 2402 | 11 | 51 | 10 | 1 | 31 | 3.1 | 4.8 | Good | P |
| 2403 | 22 | 12 | 10 | 1 | 42 | | | " | P |
| 2404 | 22 | 12 | 11 | 1 | 51 | | | " | P |
| 2405 | 22 | 12 | 9 | 2 | 15 | | 4.8 | " | P |
| 2420 | 22 | 12 | 6 | 1 | 40 | ..... | 8.1 | " | P |
| 2421 | 23 | 11 | 6 | 1 | 51 | ..... | ..... | " | P |
| 2422 | 23 | 11 | 57 | 1 | 59 | ..... | ..... | " | P |
| 2423 | 23 | 12 | 6 | 1 | 59 | ..... | ..... | " | P |
| 2424 | 23 | 12 | 7 | 2 | 07 | ..... | ..... | " | P |
| 2425 | 23 | 12 | 8 | 2 | 20 | ..... | 6.8 | " | C |
| 2425 | 23 | 12 | 8 | 2 | 33 | ..... | 3.5 | " | C |

9-10 EDWARD VII., A. 1910

 β ORIONIS 1241 *a*.1908. Jan. 20.
G. M. T. 15^h 00^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54·0256 | | | | 1½ | 53·1058 | | | |
| 3 | 53·0008 | ·0048 | ·0350 | +40·28 | 3 | 45·2624 | ·2724 | ·0337 | +35·17 |
| 2 | 53·4440 | ·4490 | ·0467 | 53·40 | 2 | 45·2628 | | | |

Weighted mean. +41·64

 V_d -17·93 V_d -·09

Curvature -·28

Radial velocity +23·3

 β ORIONIS 1241 *b*.1908. Jan. 20.
G. M. T. 15^h 00^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54·7354 | | | | 2 | 53·1094 | | | |
| 2 | 54·0270 | | | | 3 | 45·2712 | ·2755 | ·0368 | +38·41 |
| 3 | 54·0008 | ·0048 | ·0350 | +40·28 | 2 | 45·2684 | | | |
| 1 | 53·4328 | ·4360 | ·0337 | +38·54 | | | | | |

Weighted mean. +39·23

 V_d -17·93 V_d -·09

Curvature -·28

Radial velocity +20·9

 β ORIONIS 1241 *c*.1908. Jan. 20.
G. M. T. 15^h 00^mMeasured by } J. S. PLASKETT.
Observed by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| | 54·7640 | | | | | 53·1358 | | | |
| | 54·0532 | | | | | 45·2960 | | | |
| 2 | 54·0360 | ·0130 | ·0448 | +51·56 | 3 | 45·2952 | ·2727 | ·0340 | +35·49 |
| 1 | 53·4715 | ·4485 | ·0462 | +52·83 | | | | | |

Weighted mean. +43·74

 V_d -17·93 V_d -·09

Curvature -·28

Radial velocity +25·4

SESSIONAL PAPER No. 25a

1908. Jan. 20.
G. M. T. 15^h 15^m β ORIONIS 1247 *a*.Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7385 | | | | 2 | 53.1054 | | | |
| 2 | 54.0270 | | | | 2 | 45.2652 | 2737 | 0350 | +36.53 |
| 3 | 54.0012 | 0052 | 0354 | +40.74 | 2 | 45.2653 | | | |
| 3 | 53.4384 | 4434 | 0411 | +47.00 | | | | | |

Weighted mean. +42.03

 V_a -17.93 V_d -09

Curvature -28

Radial velocity +23.7

1908. Jan. 20.
G. M. T. 15^h 15^m β ORIONIS 1242 *b*.Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----------------|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7430 | | | | 2 | 53.1110 | | | |
| 1 | 54.0320 | | | | 3 | 45.2740 | 2783 | 0396 | +41.34 |
| 2 $\frac{1}{2}$ | 54.0078 | 0078 | 0380 | +43.76 | 2 | 45.2692 | | | |
| 1 $\frac{1}{2}$ | 53.4467 | 4467 | 0444 | 50.75 | | | | | |

Weighted mean. +44.22

 V_a -17.93 V_d -09

Curvature -28

Radial velocity. +25.9

1908. Jan. 20.
G. M. T. 15^h 15^m β ORIONIS 1242 *c*.Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7111 | | | | 2 | 53.0790 | | | |
| 1 | 54.0022 | | | | 2 | 45.2307 | 2655 | 0268 | +27.97 |
| 3 | 53.9678 | 9990 | 0292 | +33.61 | 2 | 45.2378 | | | |
| 2 | 53.4174 | 4500 | 0477 | +54.55 | | | | | |

Weighted mean. +37.98

 V_a -17.93 V_d -09

Curvature -28

Radial velocity. +19.7

9-10 EDWARD VII., A. 1910

 β ORIONIS 1243 *a*.1908. Jan. 20.
G. M. T. 15^h 27^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7409 | | | | 2 | 53 1154 | | | |
| 2 | 54 0332 | | | | 3 | 45 2837 | 2760 | 0373 | -38.93 |
| 3 | 54 0104 | 0064 | 0366 | -42.12 | | 45 2814 | | | |
| 2 | 53 4376 | 4346 | 0323 | 36.94 | | | | | |

Weighted mean..... -39.63

 V_a 17.93 V_d09

Curvature..... .28

Radial velocity..... 21.3

 β ORIONIS 1243 *b*.1908. Jan. 20.
G. M. T. 15^h 27^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7300 | | | | 2 | 53 1011 | | | |
| 2 | 54 0188 | | | | 3 | 45 2702 | 2730 | 0343 | +35.80 |
| 2 | 53 9988 | 0098 | 0400 | -46.04 | | 45 2712 | | | |
| 2 | 53 4319 | 4429 | 0406 | 46.43 | | | | | |

Weighted mean..... -41.76

 V_a -17.93 V_d09

Curvature..... .28

Radial velocity..... +23.5

 β ORIONIS 1243 *c*.1908. Jan. 20.
G. M. T. 15^h 27^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7244 | | | | 2 | 53 0980 | | | |
| 2 | 54 0125 | | | | 3 | 45 2705 | 2820 | 0433 | +45.19 |
| 2 | 53 9841 | 0060 | 0302 | -34.76 | | 45 2622 | | | |
| 2 | 53 4295 | 4445 | 0422 | 48.26 | | | | | |

Weighted mean..... -43.09

 V_a -17.93 V_d09

Curvature..... .28

Radial velocity..... -24.8

SESSIONAL PAPER No. 25a

1908. Jan. 20.
G. M. T. 15^h 47^m β ORIONIS 1244 *a*.Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7275 | | | | 2 | 53.0998 | | | |
| 2 | 54.0201 | | | | 3 | 45.2686 | 2811 | 0424 | +44.25 |
| 3 | 53.9956 | 0056 | 0358 | +41.20 | 2 | 45.2611 | | | |
| 2 | 53.1300 | 4410 | 0387 | 43.14 | | | | | |

Weighted mean. -42.82
 V_a -17.93
 V_d 09
Curvature28

Radial velocity +24.5

1908. Jan. 20.
G. M. T. 15^h 47^m β ORIONIS 1244 *b*.Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7310 | | | | 2 | 53.1050 | | | |
| 2 | 54.0209 | | | | 3 | 45.2620 | 2723 | 0336 | +35.07 |
| 3 | 53.9910 | 9990 | 0292 | +33.61 | 2 | 45.2632 | | | |
| 2 | 53.1264 | 4340 | 0317 | 36.25 | | | | | |

Weighted mean. +34.82
 V_a -17.93
 V_d 09
Curvature28

Radial velocity +16.5

1908. Jan. 20.
G. M. T. 15^h 47^m β ORIONIS 1244 *c*.Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7336 | | | | 2 | 53.1058 | | | |
| 2 | 54.0231 | | | | 3 | 45.2684 | 2780 | 0393 | +41.02 |
| 3 | 54.0019 | 0090 | 0392 | +45.11 | 2 | 45.2638 | | | |
| 2 | 53.4595 | 4460 | 0437 | 49.97 | | | | | |

Weighted mean. +44.75
 V_a -17.93
 V_d 09
Curvature28

Radial velocity +26.4

9-10 EDWARD VII., A. 1910

 β ORIONIS 1245 *a*.1908. Jan. 20.
G. M. T. 15^h 53^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7272 | ..... | ..... | ..... | 2 | 53.1918 | ..... | ..... | ..... |
| 1 | 54.0156 | ..... | ..... | ..... | 3 | 45.2650 | .2763 | .0376 | +39.24 |
| 3 | 53.9966 | .0090 | .0392 | +45.12 | 2 | 45.2622 | ..... | ..... | ..... |
| 2 | 53.4315 | .4430 | .0407 | 46.54 | | | | | |

Weighted mean..... +43.27

 V_a -17.93 V_d09

Curvature..... .28

Radial velocity..... +25.0

 β ORIONIS 1245 *b*.1908. Jan. 20.
G. M. T. 15^h 53^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7467 | ..... | ..... | ..... | 2 | 53.1202 | ..... | ..... | ..... |
| 2 | 54.0342 | ..... | ..... | ..... | 3 | 45.2774 | .2750 | .0363 | +37.89 |
| 3 | 54.0134 | .0074 | .0376 | +43.27 | 2 | 45.2760 | ..... | ..... | ..... |
| 2 | 53.4430 | .4340 | .0337 | 38.53 | | | | | |

Weighted mean..... +40.07

 V_a -17.93 V_d09

Curvature..... .28

Radial velocity..... +21.8

 β ORIONIS 1245 *c*.1908. Jan. 20.
G. M. T. 15^h 53^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7458 | ..... | ..... | ..... | 2 | 53.1193 | ..... | ..... | ..... |
| 2 | 54.0321 | ..... | ..... | ..... | 3 | 45.2750 | .2740 | .0353 | +36.84 |
| 3 | 54.0084 | .0034 | .0336 | +38.67 | 2 | 45.2742 | ..... | ..... | ..... |
| 2 | 53.4436 | .4390 | .0367 | 41.97 | | | | | |

Weighted mean..... +38.81

 V_a -17.93 V_d09

Curvature..... .28

Radial velocity..... +20.5

SESSIONAL PAPER No. 25a

 β ORIONIS 1249 a.1908. Jan. 20.
G. M. T. 16^h 37^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7444 | ..... | ..... | ..... | 2 | 53.1200 | ..... | ..... | ..... |
| 2 | 54.0334 | ..... | ..... | ..... | 3 | 45.2714 | 2663 | .0291 | +39.37 |
| 3 | 54.0037 | .0087 | .0289 | +33.26 | 2 | 45.2782 | ..... | ..... | ..... |
| 2 | 53.4376 | 4320 | .0297 | 33.96 | | | | | |

Weighted mean +32.35

 V_a 17.43 V_d 09

Curvature28

Radial velocity +14.0

 β ORIONIS 1247 a.1908. Jan. 20.
G. M. T. 16^h 17^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7364 | ..... | ..... | ..... | 2 | 53.1070 | ..... | ..... | ..... |
| 1 | 54.0227 | ..... | ..... | ..... | 2 | 45.2606 | 2715 | .0327 | +34.13 |
| 3 | 54.0078 | .0138 | .0440 | +50.64 | 2 | 45.2624 | ..... | ..... | ..... |
| 2 | 53.4296 | .4350 | .0327 | 37.40 | | | | | |

Weighted mean +42.14

 V_a 17.93 V_d 09

Curvature28

Radial velocity +23.8

 β ORIONIS 1247 b.1908. Jan. 20.
G. M. T. 16^h 17^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7274 | ..... | ..... | ..... | 2 | 53.0931 | ..... | ..... | ..... |
| 1 | 54.0096 | ..... | ..... | ..... | 3 | 45.2634 | 2794 | .0397 | +41.43 |
| 3 | 53.9963 | .0135 | .0437 | +50.29 | 2 | 45.2577 | ..... | ..... | ..... |
| 2 | 53.4377 | .4557 | .0534 | 61.06 | | | | | |

Weighted mean +49.66

 V_a 17.93 V_d 09

Curvature28

Radial velocity +31.3

9-10 EDWARD VII., A. 1910

 β ORIONIS 1247c.1908. Jan. 20.
G. M. T. 16^h 17^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54° 7281 | ..... | ..... | ..... | 2 | 53° 0985 | ..... | ..... | ..... |
| 1 | 54° 0124 | ..... | ..... | ..... | 3 | 45° 2528 | 2692 | 0395 | +31 83 |
| 3 | 53° 9902 | 0948 | 0350 | + 40 28 | 2 | 45° 2570 | ..... | ..... | ..... |
| 2 | 53° 4238 | 4386 | 0363 | 41 51 | | | | | |

Weighted mean - 37 42

 V_a -17 93 V_d 09

Curvature 28

Radial velocity +19 0

 β ORIONIS 1248 a.1908. Jan. 20
G. M. T. 16^h 27^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54° 7473 | ..... | ..... | ..... | 2 | 53° 1167 | ..... | ..... | ..... |
| 1 | 54° 0314 | ..... | ..... | ..... | 2 | 45° 2794 | ..... | ..... | ..... |
| 2 | 53° 9942 | 9900 | 0211 | + 24 28 | 3 | 45° 2792 | 2735 | 0348 | +36 32 |
| 1 | 53° 4267 | 4220 | 0197 | 22 53 | | | | | |

Weighted mean -30 01

 V_a -17 93 V_d 09

Curvature 28

Radial velocity -11 6

 β ORIONIS 1248 b.1908. Jan. 20.
G. M. T. 16^h 27^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54° 7402 | ..... | ..... | ..... | 2 | 53° 1140 | ..... | ..... | ..... |
| 1 | 54° 0234 | ..... | ..... | ..... | 3 | 45° 2624 | 2660 | 0273 | +28 49 |
| 1 | 53° 9742 | 9760 | 0071 | + 8 17 | 2 | 45° 2770 | ..... | ..... | ..... |
| 1 | 53° 4253 | 4260 | 0237 | 27 10 | | | | | |

Weighted mean +24 15

 V_a -17 93 V_d 09

Curvature 28

Radial velocity + 5 8

SESSIONAL PAPER No. 25a

 β ORIONIS 1248 *c*.1908, Jan. 20.
G. M. T. 16^h 27^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7472 | | | | 2 | 53.1250 | | | |
| 1 | 54.0420 | | | | 3 | 45.2991 | 2891 | 0504 | +52.60 |
| 2 | 54.0294 | 0174 | 0505 | +58.12 | 2 | 45.2836 | | | |
| 2 | 53.4593 | 4493 | 0470 | 53.75 | | | | | |

Weighted mean +54.51
 V_a 17.93
 V_d 09
 Curvature28
 Radial velocity +36.1

 β ORIONIS 1249 *b*.1908, Jan. 20.
G. M. T. 16^h 37^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7478 | | | | 2 | 53.1232 | | | |
| 2 | 54.0356 | | | | 3 | 45.2788 | 2680 | 0293 | +30.58 |
| 2 | 54.0084 | 0004 | 0306 | +35.22 | — | 45.2844 | | | |
| 2 | 53.4450 | 4365 | 0342 | 39.11 | | | | | |

Weighted mean +34.34
 V_a -17.93
 V_d 09
 Curvature28
 Radial velocity +16.0

 β ORIONIS 1249 *c*.1908, Jan. 20.
G. M. T. 16^h 37^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7362 | | | | 2 | 53.1092 | | | |
| 2 | 54.0240 | | | | 3 | 45.2725 | 2760 | 0373 | +38.93 |
| 2 | 53.9998 | 0040 | 0342 | +39.36 | — | 45.2704 | | | |
| 2 | 53.4435 | 4473 | 0451 | 51.57 | | | | | |

Weighted mean +42.66
 V_a -17.93
 V_d 09
 Curvature28
 Radial velocity +24.2

9-10 EDWARD VII., A. 1910

 γ ORIONIS 1285 *a*.1908. Jan. 27.
G. M. T. 15^h 30^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 56.2642 | | | | 2 | 54.8480 | | | |
| 2 | 56.2207 | 2768 | 0470 | +35.17 | 1½ | 42.3191 | 3130 | 0520 | +32.61 |
| 1½ | 55.4517 | 4083 | 0539 | 39.88 | 2 | 42.3130 | | | |

Weighted mean..... +35.81

 V_a -29.08 V_d -16

Curvature..... -30

Radial velocity..... +15.3

 β ORIONIS 1285 *b*.1908. Jan. 27.
G. M. T. 15^h 30^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 57.3871 | | | | 2 | 54.8307 | | | |
| 2 | 56.2462 | | | | 2 | 42.3000 | 3283 | 0673 | +42.20 |
| 2 | 56.1983 | 2724 | 0426 | +31.88 | 1½ | 42.3092 | | | |
| 1 | 55.3500 | 4241 | 0697 | 51.53 | | | | | |

Weighted mean..... +39.72

 V_a -20.08 V_d -16

Curvature..... -50

Radial velocity..... +19.2

 β ORIONIS 1285 *c*.1908. Jan. 27.
G. M. T. 15^h 30^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 57.3127 | | | | 2 | 54.8130 | | | |
| 2 | 56.2255 | | | | 2 | 42.2834 | | | |
| 2 | 56.1773 | 2718 | 0420 | +31.43 | 1½ | 42.2936 | 3293 | 0683 | +42.83 |
| 2 | 55.3222 | 4147 | 0603 | 44.62 | | | | | |

Weighted mean..... +39.38

 V_a -20.08 V_d -16

Curvature..... -30

Radial velocity..... +17.9

SESSIONAL PAPER No. 25a

 β ORIONIS 1286 *a*.1908. Jan. 27.
G. M. T. 16^h 09^m.Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 57.2727 | | | | 2 | 54.7770 | | | |
| 2 | 56.1937 | | | | 2 | 42.2466 | | | |
| 2 | 56.1589 | 2869 | .0571 | +42.73 | 1½ | 42.2512 | 3227 | .0617 | +38.6 |
| 2 | 55.2850 | 4130 | .0586 | 43.36 | | | | | |

Weighted mean +42.20

 V_a -20.08 V_d -19

Curvature 30

Radial velocity -21.3

 β ORIONIS 1286 *b*.1908. Jan. 27.
G. M. T. 16^h 09^m.Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 57.3533 | | | | 2 | 54.8539 | | | |
| 2 | 56.2632 | | | | 2 | 42.3240 | | | |
| 2 | 56.2297 | 2848 | .0550 | +41.16 | 1½ | 42.3241 | 3192 | .0582 | +36.50 |
| 1½ | 55.3552 | 4074 | .0530 | 39.21 | | | | | |

Weighted mean +39.17

 V_a -20.08 V_d -20

Curvature -28

Radial velocity +18.7

 β ORIONIS 1286 *c*.1908. Jan. 27.
G. M. T. 16^h 09^m.Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 57.3761 | | | | 2 | 54.8777 | | | |
| 2 | 56.2915 | | | | 2 | 42.3443 | | | |
| 2 | 56.2610 | 2898 | .0600 | +44.90 | 2 | 42.3548 | 3296 | .0686 | +43.02 |
| 2 | 55.3896 | 4175 | .0631 | 46.68 | | | | | |

Weighted mean +44.87

 V_a -20.08 V_d 19

Curvature -30

Radial velocity +24.3

9-10 EDWARD VII., A. 1910

 β ORIONIS 1289 a.1908. Jan. 27.
G. M. T. 17^h 17^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 57°3477 | | | | 2 | 54°8500 | | | |
| 2 | 56°2633 | | | | 3 | 42°3258 | 3168 | 0558 | +34°99 |
| 2 | 56°2241 | 1671 | 0627 | +46°92 | 2 | 42°3286 | | | |
| 1½ | 55°3630 | 3070 | 0474 | 35 07 | | | | | |

Weighted mean. +38 62

 V_r -20 08 V_d -19

Curvature -30

Radial velocity. +18.1

 β ORIONIS 1289 b.1908. Jan. 27.
G. M. T. 17^h 17^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 57°3801 | | | | 2 | 54°8794 | | | |
| 1 | 56°2921 | | | | 3 | 42°3664 | 3276 | 0665 | +41°70 |
| 3 | 56°2507 | 2780 | 0482 | +36°07 | 2 | 42°3584 | | | |
| 2 | 55°3890 | 4155 | 0611 | 45°21 | | | | | |

Weighted mean. +40°46

 V_r -20 08 V_d -19

Curvature -30

Radial velocity. +19.9

 β ORIONIS 1289 c.1908. Jan. 27.
G. M. T. 17^h 17^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 57°3608 | | | | 2 | 54°8612 | | | |
| 2 | 56°2675 | | | | 3 | 42°3602 | 3425 | 0815 | +51°11 |
| 3 | 56°2378 | 2900 | 0602 | +45°06 | 2 | 42°3378 | | | |
| 2 | 55°3721 | 4200 | 0656 | 48°54 | | | | | |

Weighted mean. +48°19

 V_r -20 08 V_d -19

Curvature -30

Radial velocity. +27.8

SESSIONAL PAPER No. 25a

 β ORIONIS 1290 *a*.1908, Jan. 27.
G. M. T. 17^h 28^mObserved by } J. S. PLASKETT
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|-------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 57.3519 | | | | 2 | 54.8582 | | | |
| 2 | 56.2658 | | | | 2 | 42.3268 | 3156 | 0546 | +34.24 |
| 3 | 56.2360 | 2800 | 0502 | +37.56 | 2 | 42.3308 | | | |

Weighted mean + 36.23

 V_a - 20.08 V_d - 19

Curvature - 30

Radial velocity + 15.6

 β ORIONIS 1290 *b*.1908, Jan. 27.
G. M. T. 17^h 28^mObserved by } J. S. PLASKETT
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|-------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 57.3527 | | | | 2 | 54.8596 | | | |
| 2 | 56.2622 | | | | 2 | 42.3223 | 3190 | 0580 | +36.37 |
| 3 | 56.2360 | 2940 | 0642 | +48.04 | 2 | 42.3224 | | | |
| 2 | 55.3534 | 4074 | 0530 | 39.21 | | | | | |

Weighted mean + 42.18

 V_a - 20.08 V_d - 19

Curvature - 30

Radial velocity + 21.6

 β ORIONIS 1290 *c*.1908, Jan. 27.
G. M. T. 17^h 28^mObserved by } J. S. PLASKETT
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----------------|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 57.3590 | | | | 2 | 54.8680 | | | |
| 2 | 56.2706 | | | | 3 | 42.3490 | 3513 | 0503 | +31.54 |
| 3 | 56.2320 | 2810 | 0512 | +38.31 | 2 | 42.3368 | | | |
| 1 $\frac{1}{2}$ | 55.3704 | 4134 | 0590 | 43.65 | | | | | |

Weighted mean + 36.70

 V_a - 20.08 V_d - 19

Curvature - 30

Radial velocity + 16.1

9-10 EDWARD VII., A. 1910

 δ ORIONIS 1405.1908. Mar. 20.
G. M. T. 11^h 51^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3300 | ..... | ..... | ..... | 2 | 58.7869 | ..... | ..... | ..... |
| 2 | 61.3502 | ..... | ..... | ..... | 2 | 36.2090 | .2170 | .1265 | +44.48 |
| 2 | 61.3121 | 3064 | .1259 | -52.05 | 2 | 36.1858 | ..... | ..... | ..... |
| 1½ | 59.7292 | .7236 | .1271 | 52.00 | | | | | |

Weighted mean..... -48.37

V_a..... 24.86V_d..... .14

Curvature..... .28

Radial velocity..... +23.1

 δ ORIONIS 1406.1908. Mar. 20.
G. M. T. 12^h 07^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3238 | ..... | ..... | ..... | 2 | 58.7846 | ..... | ..... | ..... |
| 2 | 61.3466 | ..... | ..... | ..... | 1½ | 36.2180 | .2235 | .1330 | +46.76 |
| 2 | 61.3115 | 3065 | .1290 | -53.33 | 2 | 36.1886 | ..... | ..... | ..... |
| 1½ | 59.7150 | .7122 | .1157 | 47.33 | | | | | |

Weighted mean..... +49.56

V_a..... -24.86V_d..... .14

Curvature..... .28

Radial velocity..... +24.3

 δ ORIONIS 1407.1908. Mar. 20.
G. M. T. 12^h 21^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3248 | ..... | ..... | ..... | 2 | 58.7785 | ..... | ..... | ..... |
| 2 | 61.3441 | ..... | ..... | ..... | 2 | 36.1872 | .2090 | .1185 | +41.66 |
| 3 | 61.2936 | .2941 | .1136 | +46.96 | 2 | 36.1721 | ..... | ..... | ..... |
| 1½ | 59.7240 | .7260 | .1295 | 52.98 | | | | | |

Weighted mean..... +46.72

V_a..... -24.86V_d..... .14

Curvature..... .28

Radial velocity..... +21.4

SESSIONAL PAPER No. 25a

 β ORIONIS 1408.1908. Mar. 20.
G. M. T. 12^h 32^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63 3338 | ..... | ..... | ..... | 2 | 58 7904 | ..... | ..... | ..... |
| 2 | 61 3533 | ..... | ..... | ..... | 2 | 36 2218 | 2315 | 1410 | +49.58 |
| 2 | 61 3036 | 2946 | 1141 | -47.17 | 1½ | 36 1832 | ..... | ..... | ..... |
| 1½ | 59 7392 | 7302 | 1337 | 54.70 | | | | | |

Weighted mean..... +50.15

 V_a 24.86 V_d 14

Curvature..... 28

Radial velocity..... +24.9

 β ORIONIS 1409.1908. Mar. 20.
G. M. T. 12^h 46^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63 3224 | ..... | ..... | ..... | 1 | 58 7782 | ..... | ..... | ..... |
| 2 | 61 3452 | ..... | ..... | ..... | 2 | 36 2226 | 2365 | 1460 | +51.33 |
| 2 | 61 3028 | 3048 | 1243 | +51.39 | 2 | 36 1801 | ..... | ..... | ..... |
| 1½ | 59 7364 | 7390 | 1425 | 58.30 | | | | | |

Weighted mean..... +53.25

 V_a 24.86 V_d 14

Curvature..... 28

Radial velocity..... +28.0

 β ORIONIS 1410.1908. Mar. 20.
G. M. T. 13^h 00^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63 3280 | ..... | ..... | ..... | 2 | 58 7856 | ..... | ..... | ..... |
| 2 | 61 3492 | ..... | ..... | ..... | 2 | 36 2229 | 2265 | 1360 | +47.82 |
| 2 | 61 3050 | 3010 | 1205 | +49.81 | 2 | 36 1906 | ..... | ..... | ..... |
| 1½ | 59 7178 | 7136 | 1171 | 47.91 | | | | | |

Weighted mean..... +48.57

 V_a 24.86 V_d 14

Curvature..... 28

Radial velocity..... +23.3

9-10 EDWARD VII., A. 1910

 γ ORIONIS 1411.1908. March 20.
G. M. T. 13^h 12^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.1088 | | | | 2 | 58.5647 | | | |
| 3 | 61.0842 | 61.2989 | +1184 | +48.95 | 2 | 35.9590 | | | |
| 1½ | 59.5095 | 59.7259 | 1294 | 52.94 | 2 | 6.9551 | 36.2203 | 1298 | -45.64 |

Weighted mean..... +48.85

 V_a -24.86 V_d -17

Curvature..... -28

Radial velocity..... -23.5

 β ORIONIS 1412.1908. March 20.
G. M. T. 13^h 27^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.1178 | | | | 2 | 58.5736 | | | |
| 3 | 61.0974 | 61.3005 | 1200 | -49.60 | 2 | 35.9727 | | | |
| 2 | 59.5242 | 59.7314 | 1349 | 55.18 | 2 | 36.0000 | 36.2215 | 1310 | -46.06 |

Weighted mean..... -50.18

 V_a -24.86 V_d -17

Curvature..... -28

Radial velocity..... +24.9

 β ORIONIS 1413.1908. March 20.
G. M. T. 13^h 47^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dis in Rev ^{ns} | Vel ^{ty} . |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-----------------------------|---------------------|
| 2 | 63.3873 | | | | 2 | 58.8412 | | | |
| 3 | 61.3699 | 61.3083 | 1278 | +52.83 | 2 | 36.3010 | 36.2455 | 1550 | +54.50 |
| 1½ | 59.7810 | 59.7205 | 1240 | 50.73 | 2 | 36.2495 | | | |

Weighted mean..... +52.86

 V_a -24.86 V_d -17

Curvature..... -28

Radial velocity..... +27.5

SESSIONAL PAPER No. 25a

 β ORIONIS 1414.1908. March 20.
G. M. T. 13^h 57^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63° 39' 27" | | | | 2 | 58° 8' 48" | | | |
| 3 | 61° 36' 95" | 61° 30' 15" | 1210 | +50° 02' | 2 | 36° 29' 81" | 36° 23' 50" | 1445 | +54° 40' |
| 2 | 59° 7' 945" | 59° 7' 270" | 1350 | 53° 38' | 2 | 36° 25' 72" | | | |

Weighted mean +52° 23'
 V_a -24° 86'
 V_d -17'
 Curvature -28"

Radial velocity +26° 9'

 β ORIONIS 1426.1908. March 24.
G. M. T. 12^h 03^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63° 3' 455" | | | | 2 | 58° 7' 935" | | | |
| 2 | 61° 2' 946" | 61° 2' 780" | 9975 | +40° 35' | 1½ | 36° 1' 955" | 36° 2' 300" | 1395 | +40° 05' |
| 1½ | 59° 7' 192" | 59° 7' 040" | 1075 | 43° 38' | 2 | 36° 1' 592" | | | |

Weighted mean +44° 05'
 V_a -24° 36'
 V_d -16'
 Curvature -28"

Radial velocity +19° 2'

 β ORIONIS 1427.1908. March 24.
G. M. T. 12^h 15^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63° 33' 82" | | | | 2 | 58° 7' 912" | | | |
| 2 | 61° 2' 918" | 61° 2' 798" | 9963 | +41° 09' | 2 | 36° 2' 085" | 36° 2' 340" | 1435 | +50° 45' |
| 1 | 59° 7' 208" | 59° 7' 098" | 1133 | 46° 35' | 2 | 36° 1' 682" | | | |

Weighted mean +45° 89'
 V_a -24° 36'
 V_d -16'
 Curvature -28"

Radial velocity +21° 1'

9-10 EDWARD VII., A. 1910

 β ORIONIS 1428.1908. March 24.
G. M. T. 12^h 23^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3148 | ..... | ..... | ..... | 2 | 58.7726 | ..... | ..... | ..... |
| 2 | 61.2682 | 61.2772 | .0967 | -40.01 | 2 | 36.1834 | 36.2235 | .1350 | +47.47 |
| 1½ | 59.6971 | 59.7060 | .1095 | 44.86 | 2 | 36.1522 | ..... | ..... | ..... |

Weighted mean..... +44.03

 V_a -24.36 V_d -16

Curvature .. -28

Radial velocity..... +19.2

 β ORIONIS 1429.1908. March 24.
G. M. T. 12^h 36^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3133 | ..... | ..... | ..... | 2 | 58.7619 | ..... | ..... | ..... |
| 2 | 61.2675 | 61.2825 | .1020 | -42.21 | 2 | 36.1559 | 36.2215 | .1310 | +46.06 |
| 1½ | 59.6988 | 59.7160 | .1195 | 48.89 | 2 | 36.1282 | ..... | ..... | ..... |

Weighted mean..... +45.43

 V_a -24.26 V_d -16

Curvature .. -28

Radial velocity..... +21.6

 β ORIONIS 1430.1908. March 24.
G. M. T. 12^h 42^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3288 | ..... | ..... | ..... | 2 | 58.7792 | ..... | ..... | ..... |
| 2 | 61.2808 | 61.2796 | .0995 | +41.17 | 1½ | 36.1830 | 36.2190 | .1285 | +45.18 |
| 1½ | 59.7068 | 59.7075 | .1110 | 45.41 | 2 | 36.1581 | ..... | ..... | ..... |

Weighted mean..... +43.65

 V_a -24.36 V_d -16

Curvature .. -28

Radial velocity..... +18.8

SESSIONAL PAPER No. 25a

1908. March 24.
G. M. T. 12^h 52^m δ ORIONIS 1431.Observed by } J. S. PLASKETT
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----------------|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3248 | ..... | ..... | ..... | 2 | 58.7802 | ..... | ..... | ..... |
| 2 | 61.2775 | 61.2775 | .0970 | +40.14 | 2 | 36.1932 | 36.2350 | .1445 | +50.81 |
| 1 $\frac{1}{2}$ | 59.6884 | 59.6890 | .0025 | +37.84 | 2 | 36.1520 | ..... | ..... | ..... |

Weighted mean..... +43.39

 V_d -24.36 V_d -16

Curvature..... -28

Radial velocity..... +18.6

 β ORIONIS 1433.1908. March 24.
G. M. T. 13^h 16^mObserved by } J. S. PLASKETT
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----------------|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3394 | ..... | ..... | ..... | 2 | 58.7740 | ..... | ..... | ..... |
| 2 | 61.2791 | 61.2816 | .1011 | +41.84 | 2 | 36.1666 | 36.2106 | .1201 | +42.23 |
| 1 $\frac{1}{2}$ | 59.6956 | 59.7020 | .1055 | 43.16 | 2 | 36.1490 | ..... | ..... | ..... |

Weighted mean..... +42.34

 V_d -24.36 V_d -16

Curvature..... -28

Radial velocity..... +17.5

 β ORIONIS 1434.1908. March 24.
G. M. T. 13^h 32^mObserved by } J. S. PLASKETT
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3430 | ..... | ..... | ..... | 2 | 58.7969 | ..... | ..... | ..... |
| 2 | 61.2968 | 61.2790 | .0985 | +40.76 | 1 | 36.2018 | 36.2210 | .1305 | +45.88 |
| 1 | 59.7385 | 59.7215 | .1254 | 51.30 | 2 | 36.1742 | ..... | ..... | ..... |

Weighted mean..... +44.08

 V_d -24.36 V_d -16

Curvature..... -28

Radial velocity..... +19.3

9-10 EDWARD VII., A. 1910

 β ORIONIS 1435.1908. March 24.
G. M. T. 13^h 39^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3082 | | | | 2 | 58.7515 | | | |
| 2 | 61.2508 | 61.2727 | .0922 | -38.15 | 1½ | 36.1366 | 36.2126 | .1221 | -42.93 |
| 1 | 59.6764 | 59.7034 | .1069 | 43.32 | 2 | 36.1180 | | | |

Weighted mean -40.89
 V_a -24.36
 V_d 16
Curvature 28
Radial velocity..... -16.1

 β ORIONIS 1436.1908. March 24.
G. M. T. 13^h 48^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3496 | | | | 2 | 58.8030 | | | |
| 2 | 61.2902 | 61.2762 | .0957 | 39.60 | 1½ | 36.2036 | 36.2310 | .1405 | +49.40 |
| 1½ | 59.7106 | 59.6876 | .0921 | 37.68 | 2 | 36.1692 | | | |

Weighted mean..... -41.96
 V_a -24.36
 V_d 16
Curvature 28
Radial velocity... .. 17.2

 β ORIONIS 1437.1908. March 24
G. M. T. 13^h 5.6^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3020 | | | | 2 | 58.7548 | | | |
| 1½ | 61.2558 | 61.2800 | .0995 | -41.17 | 2 | 36.1466 | 36.2180 | .1275 | +44.83 |
| 1 | 59.6798 | 59.7050 | .1085 | 44.39 | 2 | 36.1222 | | | |

Weighted mean..... +43.51
 V_a -24.36
 V_d 16
Curvature 28
Radial velocity. +18.7

SESSIONAL PAPER No. 25a

 γ ORIONIS 1438.1908, March 24.
G. M. T. 14^h 07^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3504 | | | | 2 | 58.8022 | | | |
| 1½ | 61.3018 | 61.2780 | 0975 | +40.54 | 1½ | 36.2016 | 36.2170 | 1265 | +44.48 |
| 1 | 59.7345 | 59.7125 | 1160 | 47.46 | 2 | 36.1784 | | | |

Weighted mean +43.75

 V_a -24.36 V_d 16

Curvature..... 28

Radial velocity +18.0

 δ ORIONIS 1439.1908, March 30.
G. M. T. 12^h 19^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3002 | | | | 2 | 58.7534 | | | |
| 3 | 61.2444 | 2993 | 0870 | +35.86 | 2 | 36.1192 | 1568 | 1087 | +38.11 |
| 1½ | 59.6804 | 7304 | 1066 | 43.48 | 2 | 36.1146 | | | |

Weighted mean +38.31

 V_a -23.39 V_d 21

Curvature..... 28

Radial velocity +14.4

 β ORIONIS 1440.1908, March 30.
G. M. T. 12^h 29^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3356 | | | | 2 | 58.7895 | | | |
| 2 | 61.2894 | 3087 | 0964 | +39.74 | 2 | 36.1602 | 1480 | 0999 | +35.02 |
| 1½ | 59.6994 | 7132 | 0894 | 40.54 | 2 | 36.1642 | | | |

Weighted mean +38.24

 V_a -23.39 V_d 21

Curvature..... 28

Radial velocity +14.4

9-10 EDWARD VII., A. 1910

 β ORIONIS 144L.1908, Mar. 30.
G. M. T. 12^h 38^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.4150 | | | | 2 | 58.8640 | | | |
| 2 | 61.3622 | .3042 | .0919 | +37.88 | 1½ | 36.2522 | .1620 | .1139 | +39.93 |
| 1 | 59.7768 | .7148 | .0910 | 37.12 | 2 | 36.2426 | | | |

Weighted mean +38.39

 V_a -23.39 V_d -21

Curvature -28

Radial velocity -14.5

 β ORIONIS 144Z.1908, Mar. 30.
G. M. T. 12^h 49^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3596 | | | | 2 | 58.8129 | | | |
| 2 | 61.3220 | .3175 | .1052 | +43.36 | 1½ | 36.1715 | .1572 | .1091 | +38.25 |
| 1½ | 59.7322 | .7220 | .0982 | 40.06 | 2 | 36.1666 | | | |

Weighted mean +40.84

 V_a -23.39 V_d -21

Curvature -28

Radial velocity +17.0

 β ORIONIS 144S.1908, April 3.
G. M. T. 12^h 16^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3573 | | | | 2 | 58.8206 | | | |
| 2½ | 61.3387 | .613037 | .1232 | +50.93 | 1½ | 36.2340 | .362126 | .1184 | +41.63 |
| 1½ | 59.7441 | .597160 | .1195 | 48.89 | 2 | 36.2156 | | | |

Weighted mean +48.02

 V_a -22.69 V_d -16

Curvature -28

Radial velocity +24.9

SESSIONAL PAPER No. 25a

 β ORIONIS 1449.1908. April 3.
G. M. T. 12^h 28^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3266 | | | | 2 | 58.7829 | | | |
| 2 | 61.3045 | 61.3024 | 1219 | +50.39 | 2 | 36.2068 | 36.2285 | 1380 | +48.52 |
| 1½ | 59.7338 | 59.7320 | 1355 | 55.43 | 2 | 36.1722 | | | |

Weighted mean +51.08
 V_a -22.69
 V_d -16
Curvature -28
Radial velocity +27.9

 β ORIONIS 1450.1908. April 3.
G. M. T. 12^h 40^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3216 | | | | 2 | 58.7768 | | | |
| 2 | 61.3092 | 61.3124 | 1319 | +54.53 | 1 | 36.2098 | 36.2325 | 1420 | +49.93 |
| 1½ | 59.7388 | 59.7428 | 1463 | 59.85 | 2 | 36.1714 | | | |

Weighted mean +55.28
 V_a -22.69
 V_d -16
Curvature -28
Radial velocity +32.2

 β ORIONIS 1451.1908. April 3.
G. M. T. 12^h 53^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3301 | | | | 2 | 58.7860 | | | |
| 2 | 61.3062 | 61.3007 | 1202 | +49.69 | 1½ | 36.2164 | 36.2275 | 1370 | +48.47 |
| 1½ | 59.7310 | 59.7260 | 1295 | 52.98 | 2 | 36.1830 | | | |

Weighted mean +50.22
 V_a -22.69
 V_d -16
Curvature -28
Radial velocity +27.1

9-10 EDWARD VII., A. 1913

1908. April 4.
G. M. T. 12^h 19^m β ORIONIS 1457.Observed by J. S. PLASKETT.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3698 | ..... | ..... | ..... | 2 | 58.8305 | ..... | ..... | ..... |
| 3 | 61.3515 | 61.3069 | 1264 | +52.25 | 2 | 36.2906 | 36.2530 | 1638 | +57.59 |
| 2 | 59.7708 | 59.7224 | 1259 | 51.51 | 2 | 36.2358 | ..... | ..... | ..... |

Weighted mean..... +53.56
 V_a -22.41
 V_d -22
 Curvature..... 28

Radial velocity..... +29.9

1908. April 4.
G. M. T. 12^h 28^m β ORIONIS 1458.Observed by J. S. PLASKETT.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3566 | ..... | ..... | ..... | 2 | 58.8112 | ..... | ..... | ..... |
| 2 | 61.3314 | 61.3004 | 1199 | +49.57 | 1½ | 36.2475 | 36.2460 | 1551 | +54.67 |
| 1½ | 59.7500 | 59.7196 | 1231 | 50.36 | 2 | 36.1956 | ..... | ..... | ..... |

Weighted mean..... +51.34
 V_a 22.40
 V_d 23
 Curvature..... 28

Radial velocity..... +27.4

1908. April 4.
G. M. T. 12^h 38^m β ORIONIS 1459.Observed by J. S. PLASKETT.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3648 | ..... | ..... | ..... | 2 | 58.8227 | ..... | ..... | ..... |
| 3 | 61.3354 | 61.2944 | 1139 | +47.09 | 1½ | 36.2782 | 36.2500 | 1635 | +57.13 |
| 1½ | 59.7562 | 59.7150 | 1185 | 48.47 | 2 | 36.2194 | ..... | ..... | ..... |

Weighted mean..... +49.93
 V_a -22.40
 V_d 23
 Curvature..... 28

Radial velocity..... +27.0

SESSIONAL PAPER No. 25a

 β ORIONIS 1469.1908. April 13.
G. M. T. 12^h 10^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----------------|-------------------------|--------------------------------|------------------------------|-----------|-------|-------------------------|--------------------------------|------------------------------|-----------|
| ..... | 63.8830 | ..... | ..... | ..... | ..... | 58.8337 | ..... | ..... | ..... |
| ..... | 61.4037 | ..... | ..... | ..... | ..... | 36.1867 | ..... | ..... | ..... |
| 2 $\frac{1}{2}$ | 61.3453 | 3210 | 1087 | +44.81 | 1 | 36.2037 | 1690 | 1209 | +42.38 |
| 1 $\frac{1}{2}$ | 59.7340 | 7090 | 1852 | 34.75 | | | | | |

Weighted mean +42.03

 V_d -20.23 V_d -28

Curvature -28

Radial velocity +21.3

 β ORIONIS 1470.1908. April 13.
G. M. T. 12^h 22^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-------|-------------------------|--------------------------------|------------------------------|-----------|-------|-------------------------|--------------------------------|------------------------------|-----------|
| ..... | 63.3425 | ..... | ..... | ..... | ..... | 58.7861 | ..... | ..... | ..... |
| ..... | 61.3570 | ..... | ..... | ..... | ..... | 36.1305 | ..... | ..... | ..... |
| ..... | 61.3030 | 3230 | 1107 | +45.63 | ..... | 36.1485 | 1700 | 1219 | -42.73 |
| ..... | 59.7213 | 7449 | 1202 | 49.03 | | | | | |

Weighted mean +45.75

 V_d -20.23 V_d -25

Curvature 28

Radial velocity +25.0

 β ORIONIS 1471.1908. April 13.
G. M. T. 12^h 34^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----------------|-------------------------|--------------------------------|------------------------------|-----------|-----------------|-------------------------|--------------------------------|------------------------------|-----------|
| ..... | 63.3504 | ..... | ..... | ..... | ..... | 58.7960 | ..... | ..... | ..... |
| ..... | 61.3650 | ..... | ..... | ..... | ..... | 36.1787 | ..... | ..... | ..... |
| 2 $\frac{1}{2}$ | 61.3036 | 3156 | 1033 | +42.58 | 1 $\frac{1}{2}$ | 36.1611 | 1876 | 1395 | +48.89 |
| 1 $\frac{1}{2}$ | 59.7275 | 7400 | 1162 | 47.40 | | | | | |

Weighted mean +45.61

 V_d -20.23 V_d 26

Curvature -28

Radial velocity +24.8

SESSIONAL PAPER No. 25a

 β ORIONIS 1935.1908, Oct. 13.
G. M. T. 21^h 48^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ⁿ | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ⁿ | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3626 | | | | 2 | 58.7965 | | | |
| 2 | 61.3762 | | | | 2 | 36.0878 | | | |
| 3 | 61.1940 | .2385 | .0160 | -6.58 | 1 | 35.9778 | .0000 | .0058 | 2.03 |
| 1½ | 59.6216 | .6576 | .0062 | +2.52 | | | | | |

Weighted mean..... 3.27
 V_d -20.66
 V_d16
 Curvature..... .28

Radial velocity..... +17.0

 β ORIONIS 1937.1908, Oct. 13.
G. M. T. 22^h 19^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ⁿ | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ⁿ | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3670 | | | | 2 | 58.8030 | | | |
| 2 | 61.3727 | | | | 2 | 36.0830 | | | |
| 2 | 61.2064 | .2414 | .0031 | 1.27 | 1 | 36.9604 | .9875 | .0183 | 6.50 |
| 1 | 59.6093 | .6423 | .0091 | 3.70 | | | | | |

Weighted mean..... 2.71
 V_d -29.65
 V_d11
 Curvature..... .28

Radial velocity..... +17.5

 β ORIONIS 1938.1908, Oct. 13.
G. M. T. 22^h 47^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ⁿ | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ⁿ | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3805 | | | | 2 | 58.8156 | | | |
| 2 | 61.3922 | | | | 2 | 36.1048 | | | |
| 3 | 61.2124 | .2304 | .0141 | -5.80 | 1 | 35.9790 | .9840 | .0218 | -7.62 |
| 2 | 59.6301 | .6386 | .0128 | 5.20 | | | | | |

Weighted mean..... 5.90
 V_d +20.65
 V_d18
 Curvature..... .28

Radial velocity..... -14.3

9-10 EDWARD VII., A. 1913

 β ORIONIS 1978.1908. Nov. 21.
G. M. T. 18^h 24^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. |
|---------------|-------------------|--------------------------|---|-----------|---------------|-------------------|--------------------------|---|-----------|
| 2 | 63.3468 | | | | 2 | 58.7938 | | | |
| 2 | 61.3628 | | | | 2 | 36.1436 | | | |
| 1 | 61.2132 | .2282 | .0159 | + 6.55 | $\frac{1}{2}$ | 36.0681 | .0766 | .0285 | + 9.99 |
| $\frac{1}{2}$ | 59.6547 | .6700 | .0462 | 18.75 | | | | | |

Weighted mean +10.46

 V_a + 6.82 V_d 62

Curvature28

Radial velocity +17.0

 β ORIONIS 1979.1908. Nov. 21.
G. M. T. 18^h 43^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. |
|---------------|-------------------|--------------------------|---|-----------|---------------|-------------------|--------------------------|---|-----------|
| 2 | 63.3061 | | | | 2 | 58.7652 | | | |
| 2 | 61.3300 | | | | 2 | 36.1120 | | | |
| $\frac{1}{2}$ | 61.1662 | .2174 | | | $\frac{1}{2}$ | 36.0187 | .0387 | .0106 | + 3.72 |
| 1 | 59.6741 | .6591 | .6353 | +14.39 | | | | | |

Weighted mean +10.83

 V_a + 6.82 V_d 05

Curvature28

Radial velocity +17.3

 β ORIONIS 1980.1908. Nov. 21.
G. M. T. 19^h 05^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. |
|---------------|-------------------|--------------------------|---|-----------|---------------|-------------------|--------------------------|---|-----------|
| 2 | 63.3533 | | | | 2 | 58.7995 | | | |
| 2 | 61.3671 | | | | 2 | 36.1350 | | | |
| $\frac{1}{2}$ | 61.2382 | .2480 | .0357 | +14.72 | $\frac{1}{2}$ | 36.0917 | .1090 | .0609 | +21.34 |
| 2 | 59.6646 | .6745 | .0507 | 20.58 | | | | | |

Weighted mean +18.08

 V_a + 6.82 V_d 69

Curvature28

Radial velocity +24.5

SESSIONAL PAPER No. 25a

 β ORIONIS 1981.1908. Nov. 21.
G. M. T. 19^h 33^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3651 | | | | 2 | 58.8100 | | | |
| 2 | 61.3788 | | | | 2 | 36.1536 | | | |
| 3 | 61.2564 | 2540 | 0417 | +17.19 | 1 | 36.1135 | 1120 | 0639 | +22.40 |
| 1½ | 59.6711 | 6700 | 0462 | 18.75 | | | | | |

Weighted mean - 18.56
 V_a - 6.82
 V_d 13
 Curvature 28

Radial velocity..... + 25.0

 β ORIONIS 1984.1908. Nov. 28.
G. M. T. 16^h 05^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3672 | | | | 2 | 58.8125 | | | |
| 2 | 61.3818 | | | | 2 | 36.1472 | | | |
| 3 | 61.2562 | 2518 | 0395 | +16.28 | 2 | 36.1186 | 1236 | 0755 | +26.47 |
| 1½ | 59.6454 | 6418 | 0180 | 7.34 | | | | | |

Weighted mean +17.35
 V_a + 3.79
 V_d + 15
 Curvature..... - 28

Radial velocity..... + 21.0

 β ORIONIS 1985.1908. Nov. 28.
G. M. T. 16^h 34^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.4001 | | | | 2 | 58.8418 | | | |
| 2 | 61.4112 | | | | 2 | 36.1728 | | | |
| 3 | 61.2867 | 2527 | 0405 | +16.65 | 1½ | 36.1352 | 1155 | 0674 | +23.63 |
| 2 | 59.7043 | 6713 | 0475 | 19.37 | | | | | |

Weighted mean + 19.10
 V_a + 3.79
 V_d + 10
 Curvature..... - 28

Radial velocity..... + 22.7

9-10 EDWARD VII., A. 1910

 β ORIONIS 1986.1908. Nov. 28.
G. M. T. 17^h 08^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3743 | | | | 2 | 58.8170 | | | |
| 2 | 61.3865 | | | | 2 | 36.1450 | | | |
| 3 | 61.2439 | .2340 | .0217 | + 8.94 | 2 | 36.1220 | .1290 | .0869 | + 28.36 |
| 1½ | 59.6728 | .6645 | .0407 | 16.60 | | | | | |

Weighted mean +16.91
 V_a + 3.79
 V_d + .05
Curvature... .. .28

Radial velocity +20.5

 β ORIONIS 1987.1908. Dec. 1.
G. M. T. 17^h 53^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3748 | | | | 2 | 58.8267 | | | |
| 2 | 61.3934 | | | | 2 | 36.2127 | | | |
| 2 | 61.2490 | .2005 | .0200 | + 8.33 | 1 | 36.1757 | .1573 | .0668 | + 23.44 |
| 1 | 59.6824 | .6385 | .0420 | 17.13 | | | | | |

Weighted mean +14.31
 V_a + 2.42
 V_d - .04
Curvature... .. .28

Radial velocity... .. +16.4

 β ORIONIS 1988.1908. Dec. 1.
G. M. T. 18^h 18^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3353 | | | | 2 | 58.7876 | | | |
| 2 | 61.3527 | | | | 2 | 36.1671 | | | |
| 2 | 61.2276 | .2515 | .0392 | + 16.16 | 1 | 36.1272 | .1123 | .0643 | + 22.54 |
| 1 | 59.6515 | .6735 | .0497 | 20.27 | | | | | |

Weighted mean +18.78
 V_a + 2.42
 V_d - .09
Curvature... .. .28

Radial velocity... .. +20.9

SESSIONAL PAPER No. 25a

 β ORIONIS 1989.1908. Dec. 1.
G. M. T. 18^h 36^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3437 | ..... | ..... | ..... | 2 | 58.7973 | ..... | ..... | ..... |
| 2 | 61.3587 | ..... | ..... | ..... | 2 | 36.1794 | ..... | ..... | ..... |
| 2 | 61.2166 | .2335 | .0212 | + 8.74 | 1½ | 35.1287 | .1015 | .0535 | +18.75 |
| ½ | 59.6620 | .6760 | .0522 | 21.29 | | | | | |

Weighted mean..... +14.06
 V_a + 2.42
 V_d12
Curvature..... .28
Radial velocity..... +16.1

 β ORIONIS 1990.1908. Dec. 1.
G. M. T. 18^h 52^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-------|-------------------------|--------------------------------|-------------------------------|-----------|-------|-------------------------|--------------------------------|-------------------------------|-----------|
| ..... | 63.3478 | ..... | ..... | ..... | ..... | 58.8000 | ..... | ..... | ..... |
| 3 | 61.3679 | ..... | ..... | ..... | ..... | 36.1850 | ..... | ..... | ..... |
| 2 | 61.2397 | .2520 | .0397 | +16.36 | 1 | 36.1648 | .1320 | .0839 | +29.41 |
| 2 | 59.6724 | .6830 | .0592 | 24.15 | | | | | |

Weighted mean..... +21.13
 V_a + 2.41
 V_d16
Curvature..... .28
Radial velocity..... +23.1

 β ORIONIS 2003.1908. Dec. 5.
G. M. T. 16^h 10^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-------|-------------------------|--------------------------------|-------------------------------|-----------|-------|-------------------------|--------------------------------|-------------------------------|-----------|
| ..... | 63.3465 | ..... | ..... | ..... | ..... | 58.8060 | ..... | ..... | ..... |
| ..... | 61.3690 | ..... | ..... | ..... | ..... | 36.2298 | ..... | ..... | ..... |
| 3 | 61.2456 | .2215 | .0410 | +16.95 | 1 | 36.2074 | .1715 | .0810 | +28.48 |
| 1½ | 59.6764 | .6518 | .0553 | 22.62 | | | | | |

Weighted mean..... +22.16
 V_a + .63
 V_d + .10
Curvature..... .28
Radial velocity..... +22.6

9-10 EDWARD VII., A. 1910

 β ORIONIS 2004.1908. Dec. 5.
G. M. T. 16^h 22^mObserved by J. S. PLASKETT.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|---------------|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63 3170 | | | | 2 | 58 7790 | | | |
| 2 | 61 3390 | | | | 2 | 36 1924 | | | |
| 2 | 61 2216 | 2275 | 0470 | 19 43 | 1 | 36 1868 | 1886 | 0981 | +34 49 |
| $\frac{1}{2}$ | 59 6557 | 6610 | 0635 | 25 98 | | | | | |

Weighted mean +24 67
 V_a + 63
 V_d + 08
 Curvature 28

Radial velocity. -25 1

 β ORIONIS 2005.1908. Dec. 5.
G. M. T. 16^h 38^mObserved by J. S. PLASKETT.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|----------------|-------------------|--------------------------|--|-----------|----------------|-------------------|--------------------------|--|-----------|
| 2 | 63 3064 | | | | 2 | 58 7707 | | | |
| 2 | 61 3304 | | | | 2 | 36 1884 | | | |
| $\frac{2}{3}$ | 61 2269 | 2415 | 0610 | 25 22 | $1\frac{1}{2}$ | 36 1715 | 1775 | 0870 | +30 59 |
| $1\frac{1}{2}$ | 59 6314 | 6450 | 0485 | 19 84 | | | | | |

Weighted mean +25 22
 V_a + 63
 V_d + 05
 Curvature 28

Radial velocity. +25 6

 β ORIONIS 2006.1908. Dec. 5.
G. M. T. 16^h 53^mObserved by J. S. PLASKETT.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|----------------|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63 3019 | | | | 2 | 58 7614 | | | |
| 2 | 61 3242 | | | | 2 | 36 1852 | | | |
| 3 | 61 2261 | 2480 | 0675 | +27 90 | 1 | 36 1782 | 1872 | 0967 | +34 00 |
| $1\frac{1}{2}$ | 59 6262 | 6480 | 0515 | 21 07 | | | | | |

Weighted mean +27 14
 V_a + 63
 V_d + 03
 Curvature 28

Radial velocity. +27 5

SESSIONAL PAPER No. 25a

 β ORIONIS 2054.1908, Dec. 21.
G. M. T. 15^h 24^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Setting. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|-------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| ... | 54 7148 | ... | ... | ... | ... | 53 0909 | ... | ... | ... |
| ... | 54 0045 | ... | ... | ... | ... | 45 2924 | ... | ... | ... |
| ... | 53 9654 | 9630 | 0198 | 22 90 | ... | 45 2894 | 2907 | 0318 | 33 39 |
| ... | 53 4020 | 4000 | 0218 | 25 05 | ... | ... | ... | ... | ... |

Weighted mean = 28 28
 V_d 6 51
 V_d 04
 Curvature 28

Radial velocity + 21 5

 β ORIONIS 2055.1908, Dec. 21.
G. M. T. 15^h 29^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7334 | ... | ... | ... | 2 | 53 1065 | ... | ... | ... |
| 2 | 53 9890 | 9690 | 0258 | + 29 84 | 1 | 45 2957 | 2907 | 0318 | + 33 39 |
| 14 | 53 4172 | 3990 | 0208 | 23 90 | 2 | 45 2891 | ... | ... | ... |

Weighted mean + 28 65
 V_d 6 51
 V_d + 03
 Curvature 28

Radial velocity + 21 9

 β ORIONIS 2057.1908, Dec. 21.
G. M. T. 16^h 54^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 56 6288 | ... | ... | ... | 2 | 53 0900 | ... | ... | ... |
| 2 | 54 7099 | ... | ... | ... | 14 | 45 2802 | 2926 | 0327 | + 34 34 |
| 2 | 53 9683 | 9695 | 0263 | + 30 42 | 2 | 45 2730 | ... | ... | ... |
| 1 | 53 4072 | 4080 | 0298 | 34 24 | ... | ... | ... | ... | ... |

Weighted mean + 32 57
 V_d 6 53
 V_d 07
 Curvature 28

Radial velocity + 25 7

9-10 EDWARD VII., A. 1910

 δ ORIONIS 2058.1908. Dec. 21.
G. M. T. 17^h 10^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 56° 6155 | | | | 2 | 58° 0753 | | | |
| 2 | 54° 6935 | | | | 1½ | 45° 2686 | °2853 | °6267 | + 28° 04 |
| 1½ | 53° 9424 | °9585 | °0143 | + 16 54 | 2 | 45° 2681 | | | |
| 1½ | 53° 3996 | °4140 | °C358 | 41° 14 | | | | | |

Weighted mean..... - 28° 91

 V_a - 6° 53 V_d - °07

Curvature..... - °28

Radial velocity..... + 22° 0

 β ORIONIS 2065.1908. Dec. 22.
G. M. T. 17^h 38^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63° 3046 | | | | 2 | 58° 7690 | | | |
| 2 | 61° 3280 | | | | 1 | 36° 2329 | | | |
| 1½ | 61° 2436 | °2278 | °0792 | + 32° 84 | 2 | 36° 2528 | °2560 | 1230 | + 45° 38 |
| 2 | 59° 6639 | °6520 | °0828 | 33° 55 | | | | | |

Weighted mean..... - 35° 50

 V_a - 6° 98 V_d - °11

Curvature..... °28

Radial velocity..... - 28° 1

 β ORIONIS 2066.1908. Dec. 22.
G. M. T. 17^h 52^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63° 2806 | | | | 2 | 58° 7610 | | | |
| 2 | 61° 3178 | | | | 2 | 36° 2286 | | | |
| 3 | 61° 2262 | °2220 | °0734 | - 30° 43 | 1 | 36° 2245 | °2320 | °0990 | + 34° 92 |
| 1½ | 59° 6270 | °6245 | °0553 | 22° 68 | | | | | |

Weighted mean..... + 29° 13

 V_a - 6° 98 V_d - °12

Curvature..... - °28

Radial velocity..... + 21° 7

SESSIONAL PAPER No. 25a

 β ORIONIS 2067.1904. Dec. 22.
G. M. T. 18^h 02^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 63.2842 | | | | 2 | 58.7512 | | | |
| 2 | 61.3040 | | | | 2 | 36.2038 | | | |
| 2 | 61.2047 | .2110 | .0624 | +25.87 | 1 | 36.2081 | .2405 | .1075 | +37.92 |
| 1 | 59.6403 | .6480 | .0788 | 32.32 | | | | | |

Weighted mean..... +30.49

 V_a 6.98 V_d 14

Curvature..... 28

Radial velocity +23.1

 β ORIONIS 2068.1908. Dec. 22.
G. M. T. 18^h 14^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 63.2842 | | | | 2 | 58.7570 | | | |
| 2 | 61.3115 | | | | 2 | 36.2160 | | | |
| 2 | 61.2151 | .2160 | .0674 | +27.94 | 1 | 36.2098 | .2300 | .0970 | +34.21 |
| 1 | 59.6468 | .6483 | .0791 | 32.45 | | | | | |

Weighted mean..... +30.63

 V_a 6.98 V_d 14

Curvature..... 28

Radial velocity +23.2

 β ORIONIS 2070.1908. Dec. 23.
G. M. T. 14^h 00^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|----------------|-------------------|--------------------------|---|-----------|---------------|-------------------|--------------------------|---|-----------|
| 3 | 63.2758 | | | | 2 | 58.7363 | | | |
| 2 | 61.2947 | | | | 2 | 36.1449 | | | |
| 3 | 61.1906 | .2490 | .0685 | +28.32 | $\frac{1}{2}$ | 36.1500 | .1990 | .1085 | +38.15 |
| $1\frac{1}{2}$ | 59.6100 | .6580 | .0615 | 25.16 | | | | | |

Weighted mean..... +28.36

 V_a 7.36 V_d 18

Curvature..... 28

Radial velocity +20.9

9-10 EDWARD VII., A. 1910

 β ORIONIS 2071.1908. Dec. 23.
G. M. T. 14^h 40^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3263 | | | | 2 | 58.7844 | | | |
| 2 | 61.3499 | | | | 2 | 36.2102 | | | |
| 3 | 61.2612 | 2580 | 0775 | +32.04 | 1 | 36.2124 | 1964 | 1059 | +37.23 |
| 1 | 59.6928 | 6920 | 0935 | 38.25 | | | | | |

Weighted mean..... +31.32
 V_a - 7.36
 V_d - .12
Curvature..... - .28
Radial velocity..... -26.8

 β ORIONIS 2072.1908. Dec. 23.
G. M. T. 15^h 08^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3214 | | | | 2 | 58.7812 | | | |
| 2 | 61.3398 | | | | 2 | 36.2100 | | | |
| 2½ | 61.2460 | 2500 | 0695 | +28.73 | 1 | 36.2152 | 1995 | 1000 | +38.32 |
| 1½ | 59.6670 | 6703 | 0738 | 30.19 | | | | | |

Weighted mean..... +31.09
 V_a - 7.36
 V_d + .09
Curvature..... - .28
Radial velocity..... +23.5

 β ORIONIS 2073.1908. Dec. 23.
G. M. T. 15^h 20^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.2965 | | | | 2 | 58.7615 | | | |
| 2 | 61.3297 | | | | 2 | 36.1916 | | | |
| 3 | 61.2222 | 2470 | 0665 | +27.49 | 1 | 36.1928 | 1954 | 1049 | +36.88 |
| 1½ | 59.6362 | 6595 | 0630 | 25.77 | | | | | |

Weighted mean..... +28.73
 V_a - 7.36
 V_d + .07
Curvature..... - .28
Radial velocity..... +21.2

SESSIONAL PAPER No. 25a

 β ORIONIS 2075.1908. Dec. 25.
G. M. T. 15^h 50^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3319 | | | | 2 | 58.7877 | | | |
| 2 | 61.3525 | | | | 2 | 36.1851 | | | |
| 3 | 61.2697 | 2622 | .0817 | +33.77 | 1½ | 36.1791 | 1882 | .0977 | +34.45 |
| 1½ | 59.6900 | 6850 | .0885 | 36.21 | | | | | |

Weighted mean 34.52
 V_a 8.68
 V_d 01
 Curvature 28
 Radial velocity 25.6

 β ORIONIS 2076.1908. Dec. 25.
G. M. T. 16^h 00^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3051 | | | | 2 | 58.7573 | | | |
| 2 | 61.3204 | | | | 2 | 36.1624 | | | |
| 3 | 61.2857 | 2500 | .0785 | +32.45 | 1½ | 36.1630 | 1950 | .1045 | +36.74 |
| 1½ | 59.6614 | 6874 | .0919 | 37.60 | | | | | |

Weighted mean +34.81
 V_a 8.68
 V_d 01
 Curvature 28
 Radial velocity 25.9

 β ORIONIS 2077.1908. Dec. 25.
G. M. T. 16^h 09^m• Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3424 | | | | 2 | 58.7943 | | | |
| 2 | 61.3008 | | | | 2 | 36.1993 | | | |
| 3 | 61.2612 | 2450 | .0645 | +26.66 | 1½ | 36.2152 | 2082 | .1177 | +41.38 |
| 1½ | 59.6842 | 6736 | .0765 | 31.30 | | | | | |

Weighted mean +31.48
 V_a 8.68
 V_d 02
 Curvature 28
 Radial velocity +22.5

9-10 EDWARD VII., A. 1910

 β ORIONIS 2078.1908. Dec. 26.
G. M. T. 16^h 18^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|---------------|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63° 3147 | ..... | ..... | ..... | 2 | 58° 7684 | ..... | ..... | ..... |
| 2 | 61° 3334 | ..... | ..... | ..... | 2 | 36° 1610 | ..... | ..... | ..... |
| 2 | 61° 2290 | 2410 | 0605 | +25° 01 | 1 | 36° 1567 | 1900 | 0995 | +34° 98 |
| $\frac{1}{2}$ | 59° 6970 | 7120 | 1135 | 46° 45 | | | | | |

Weighted mean..... +30° 92

 V_a 8° 68 V_d 04

Curvature..... 28

Radial velocity..... +22° 0

 β ORIONIS 2079.1908. Dec. 27.
G. M. T. 14^h 07^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63° 3248 | ..... | ..... | ..... | 2 | 58° 7809 | ..... | ..... | ..... |
| 2 | 61° 3453 | ..... | ..... | ..... | 2 | 36° 1593 | ..... | ..... | ..... |
| 3 | 61° 2754 | 2750 | 0945 | +39° 07 | 1 | 36° 1787 | 2140 | 1235 | +43° 42 |
| 2 | 59° 7087 | 7115 | 1150 | 47° 05 | | | | | |

Weighted mean..... +42° 45

 V_a 9° 08 V_d 15

Curvature..... 28

Radial velocity..... -33° 2

 β ORIONIS 2080.1908. Dec. 27.
G. M. T. 15^h 10^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|---------------|-------------------------|--------------------------------|--|-----------|
| 2 | 63° 3504 | ..... | ..... | ..... | 2 | 58° 8064 | ..... | ..... | ..... |
| 2 | 61° 3730 | ..... | ..... | ..... | 2 | 36° 1823 | ..... | ..... | ..... |
| 3 | 61° 3054 | 2780 | 0975 | +40° 31 | $\frac{1}{2}$ | 36° 1975 | 2095 | 1190 | +41° 84 |
| 1 | 59° 7017 | 6790 | 0825 | 33° 75 | | | | | |

Weighted mean..... +39° 02

 V_a 9° 08 V_d 05

Curvature..... 28

Radial velocity..... +29° 7

SESSIONAL PAPER No. 25a

 β ORIONIS 2082.1908. Dec. 31.
G. M. T. 15^h 19^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7142 | | | | 2 | 53.0938 | | | |
| 2 | 54.0115 | | | | 2 | 45.2860 | 2855 | .0368 | + 38.53 |
| 2 | 53.9684 | .9790 | .0224 | + 25.84 | 2 | 45.2716 | | | |
| 2 | 53.4146 | .4225 | .0323 | 37.03 | | | | | |

Weighted mean..... + 33.80

 V_a 10.77 V_d00

Curvature..... .28

Radial velocity..... + 22.7

 β ORIONIS 2083.1908. Dec. 31.
G. M. T. 15^h 23^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7063 | | | | 2 | 53.0856 | | | |
| 2 | 54.0015 | | | | 1½ | 45.2868 | 2850 | .0363 | + 38.00 |
| 2 | 53.9690 | .9860 | .0294 | 33.92 | 2 | 45.2719 | | | |
| 1 | 53.4065 | .4215 | .0313 | 35.88 | | | | | |

Weighted mean..... + 35.72

 V_a 10.77 V_d00

Curvature..... .28

Radial velocity..... + 24.7

 β ORIONIS 2084.1908. Dec. 31.
G. M. T. 15^h 29^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.6938 | | | | 2 | 53.0745 | | | |
| 2 | 53.9878 | | | | 2 | 45.2702 | 2812 | .0325 | + 34.02 |
| 2 | 53.9587 | .9880 | .0314 | + 36.23 | 2 | 45.2690 | | | |
| 1 | 53.3888 | .4160 | .0258 | 29.57 | | | | | |

Weighted mean..... + 34.01

 V_a 10.77 V_d00

Curvature..... .28

Radial velocity..... + 23.0

9-10 EDWARD VII., A. 1910

 β ORIONIS 2083.1908. Dec. 31.
G. M. T. 15^h 57^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m . | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.6907 | | | | 2 | 53.0777 | | | |
| 2 | 53.9927 | | | | 2 | 45.2854 | .2895 | .0408 | -42.71 |
| 3 | 53.9502 | .9835 | .0269 | -31.03 | 2 | 45.2717 | | | |
| 1½ | 53.4022 | .4255 | .0353 | 40.46 | | | | | |

Weighted mean + 37.57

 V_a - 10.77 V_d 00

Curvature 28

Radial velocity + 26.5

 β ORIONIS 2092.1909. Jan. 6.
G. M. T. 16^h 49^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m . | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7150 | | | | 2 | 53.0905 | | | |
| 2 | 54.0102 | | | | 1½ | 45.2713 | .2730 | .0243 | +25.44 |
| 3 | 53.9756 | .9860 | .0294 | +33.92 | 2 | 45.2734 | | | |
| 1½ | 53.4128 | .4230 | .0328 | 37.60 | | | | | |

Weighted mean + 32.72

 V_a - 13.21 V_d 16

Curvature 28

Radial velocity + 19.1

 β ORIONIS 2093.1909. Jan. 6.
G. M. T. 16^h 53^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m . | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7120 | | | | 2 | 53.0884 | | | |
| 2 | 54.0046 | | | | 2 | 45.2787 | .2750 | .0263 | +27.43 |
| 3 | 53.9727 | .9860 | .0294 | +33.92 | 2 | 45.2773 | | | |
| 1½ | 53.4136 | .4250 | .0348 | 39.89 | | | | | |

Weighted mean + 33.30

 V_a - 13.21 V_d 16

Curvature 28

Radial velocity + 19.6

SESSIONAL PAPER No. 25a

† ORIONIS 2034.

1909. Jan. 6.
G. M. T. 17^h 13^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54 7235 | ..... | ..... | ..... | 2 | 53 1074 | ..... | ..... | ..... |
| 2 | 54 0160 | ..... | ..... | ..... | 2 | 45 2057 | 2830 | 0343 | +35 81 |
| 3 | 53 9867 | 9850 | 0284 | +32 77 | 2 | 45 2876 | ..... | ..... | ..... |
| 2 | 53 4193 | 4143 | 0241 | 27 63 | | | | | |

Weighted mean..... 32 17

 V_a 13 21 V_d 16

Curvature..... 28

Radial velocity..... 18 5

β ORIONIS 2095.

1909. Jan. 6.
G. M. T. 17^h 16^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 56 6440 | ..... | ..... | ..... | 2 | 53 0690 | ..... | ..... | ..... |
| 2 | 54 7198 | ..... | ..... | ..... | 2 | 45 2880 | 2815 | 0328 | +34 34 |
| 2 | 53 9780 | 9830 | 0264 | +30 46 | 2 | 45 2821 | ..... | ..... | ..... |
| 1 | 53 4356 | 4380 | 0478 | 54 79 | | | | | |

Weighted mean..... +34 89

 V_a 13 21 V_d 16

Curvature..... 28

Radial velocity..... 21 2

β ORIONIS 2105.

1909. Jan. 7.
G. M. T. 12^h 49^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54 7033 | ..... | ..... | ..... | 2 | 53 0832 | ..... | ..... | ..... |
| 3 | 53 9964 | ..... | ..... | ..... | 1 | 45 2868 | ..... | ..... | ..... |
| 3 | 53 9552 | 9600 | 0168 | +19 43 | 2 | 45 2834 | 2902 | 0313 | +32 87 |
| 1½ | 53 4150 | 4215 | 0433 | 49 76 | | | | | |

Weighted mean..... +30 57

 V_a 13 59 V_d 11

Curvature..... 28

Radial velocity..... +16 8

9-10 EDWARD VII., A. 1910

 β ORIONIS 2106.1909 Jan. 7.
G. M. T. 13^h 01^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7102 | | | | 2 | 53.0883 | | | |
| 2 | 54.0642 | | | | 2 | 45.2895 | | | |
| 3 | 53.9710 | .9725 | .0293 | +33.89 | 1½ | 45.2880 | .2920 | .0331 | +34.76 |
| 2 | 53.4114 | .4125 | .0343 | 39.41 | | | | | |

Weighted mean. +35.79

 V_a -13.59 V_d 11

Curvature.28

Radial velocity. +21.9

 β ORIONIS 2107.1909 Jan. 7.
G. M. T. 13^h 04^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7028 | | | | 2 | 53.0852 | | | |
| 2 | 54.0000 | | | | 2 | 36.2832 | | | |
| 3 | 53.9603 | .9653 | .0221 | +25.56 | 1½ | 36.2708 | .2810 | .0221 | +23.21 |
| 1½ | 53.4016 | .4060 | .0278 | 31.94 | | | | | |

Weighted mean. +26.57

 V_a -13.59 V_d 11

Curvature.28

Radial velocity. +12.8

 β ORIONIS 2108.1909 Jan. 7.
G. M. T. 13^h 07^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7190 | | | | 2 | 53.0925 | | | |
| 1 | 54.0072 | | | | 2 | 45.2938 | | | |
| 2½ | 53.9772 | .9715 | .0283 | +32.73 | 2 | 45.2933 | .2931 | .0342 | +35.91 |
| 1½ | 53.4133 | .4097 | .0315 | 36.20 | | | | | |

Weighted mean. +34.66

 V_a -13.59 V_d 11

Curvature.28

Radial velocity. -20.7

SESSIONAL PAPER No. 25a

 β ORIONIS 2111.1909. Jan. 7.
G. M. T. 16^h 27^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|-------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3019 | ..... | ..... | ..... | 2 | 58.7700 | ..... | ..... | ..... |
| 2 | 61.3278 | ..... | ..... | ..... | 1½ | 36.2038 | 2023 | .0693 | +24.46 |
| 2 | 61.2471 | .2315 | .0829 | 34.37 | 2 | 36.2253 | ..... | ..... | ..... |
| 1 | 59.6883 | .6760 | .1068 | 43.81 | | | | | |

Weighted mean + 33.16

 V_a - 13.59 V_d 11

Curvature..... .28

Radial velocity..... +19.2

 β ORIONIS 2112.1909. Jan. 7.
G. M. T. 16^h 37^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.2779 | ..... | ..... | ..... | 2 | 58.7484 | ..... | ..... | ..... |
| 2 | 61.3633 | ..... | ..... | ..... | 1½ | 36.2003 | .2120 | .0790 | +27.86 |
| 3 | 61.2146 | .2236 | .0750 | +31.51 | 2 | 36.2131 | ..... | ..... | ..... |
| 2 | 59.6353 | .6455 | .0763 | 31.30 | | | | | |

Weighted mean..... + 30.60

 V_a - 13.59 V_d 11

Curvature..... .28

Radial velocity..... +16.6

 β ORIONIS 2114.1909. Jan. 7.
G. M. T. 16^h 56^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.2829 | ..... | ..... | ..... | 1 | 58.7582 | ..... | ..... | ..... |
| 2 | 61.3072 | ..... | ..... | ..... | 1½ | 36.1955 | 2045 | .0715 | +25.22 |
| 3 | 61.2181 | .2220 | .0734 | 30.43 | 2 | 36.2146 | ..... | ..... | ..... |
| 1½ | 59.6679 | .6695 | .1003 | 41.14 | | | | | |

Weighted mean + 31.80

 V_a - 13.59 V_d 11

Curvature..... .28

Radial velocity..... +17.8

9-10 EDWARD VII., A. 1910

† ORIONIS 2117.

1909, Jan. 8.
G. M. T. 15^h 48^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 6880 | | | | 2 | 53° 0662 | | | |
| 1 | 53° 9760 | | | | 2 | 45° 2638 | 2850 | 0261 | + 27° 41 |
| 2 | 53° 9517 | 9750 | 0318 | + 36° 78 | 2 | 45° 2622 | | | |
| 1 | 53° 3882 | 4113 | 0331 | 38° 04 | | | | | |

Weighted mean..... - 33° 28

 V_a 13° 96 V_d 09

Curvature..... 28

Radial velocity..... - 18° 9

β ORIONIS 2118.

1909, Jan. 8.
G. M. T. 15^h 52^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7077 | | | | 2 | 53° 0872 | | | |
| 2 | 53° 9948 | | | | 2 | 45° 2898 | 2935 | 0346 | + 36° 33 |
| 2 | 53° 9690 | 9730 | 0298 | - 34° 47 | 2 | 45° 2837 | | | |
| 1 | 53° 4030 | 4060 | 0278 | 31° 84 | | | | | |

Weighted mean..... + 34° 69

 V_a 13° 96 V_d 09

Curvature..... 28

Radial velocity..... + 20° 3

β ORIONIS 2122.

1909, Jan. 12.
G. M. T. 11^h 55^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7074 | | | | 2 | 53° 0858 | | | |
| 2 | 53° 9968 | | | | 2 | 45° 2886 | | | |
| 1½ | 53° 9604 | 9735 | 0303 | + 33° 80 | 2 | 45° 2856 | 2905 | 0316 | + 34° 92 |
| 2 | 53° 4238 | 4275 | 0493 | 54° 97 | | | | | |

Weighted mean..... + 41° 91

 V_a 15° 39 V_d + 23

Curvature..... 28

Radial velocity..... + 26° 5

SESSIONAL PAPER No. 25a

 β ORIONIS 2123.1909. Jan. 12.
G. M. T. 11^h 59^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7088 | | | | 2 | 53° 0880 | | | |
| 2 | 53° 9990 | | | | 2 | 45° 2791 | | | |
| 3 | 53° 9836 | 9836 | 0428 | 47.75 | 1 | 45° 2727 | 2890 | 0301 | 33.26 |
| 2 | 53° 4085 | 4105 | 0323 | 36.01 | | | | | |

Weighted mean..... + 41.42
 V_d - 15.39
 V_d + .23
 Curvature..... .28

Radial velocity..... - 26.0

 β ORIONIS 2124.1909. Jan. 12.
G. M. T. 12^h 06^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7008 | | | | 2 | 53° 0750 | | | |
| 2 | 53° 9928 | | | | 2 | 45° 2813 | | | |
| 3 | 53° 9598 | 9700 | 0268 | + 29.90 | 2 | 45° 2783 | 2905 | 0316 | + 34.92 |
| 1½ | 53° 4100 | 4225 | 0443 | 49.39 | | | | | |

Weighted mean..... + 35.97
 V_d 15.39
 V_d + .23
 Curvature..... .28

Radial velocity..... - 20.5

 β ORIONIS 2125.1909. Jan. 12.
G. M. T. 12^h 12^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7110 | | | | 2 | 53° 0858 | | | |
| 2 | 54° 0045 | | | | 2 | 45° 2870 | | | |
| 4 | 53° 9770 | 9775 | 0343 | + 38.27 | 2 | 45° 2840 | 2905 | 0316 | + 34.92 |
| 3 | 53° 4077 | 4105 | 0323 | 36.01 | | | | | |

Weighted mean..... + 36.77
 V_d - 15.39
 V_d + .23
 Curvature..... .28

Radial velocity..... + 21.3

9-10 EDWARD VII., A. 1910

 β ORIONIS 2126.1909. Jan. 12.
G. M. T. 12^h 15^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 54.7047 | | | | 2 | 53.0813 | | | |
| 2 | 54.0000 | | | | 2 | 45.2910 | | | |
| 2½ | 53.9770 | 9830 | 0398 | +44.40 | 1 | 45.2885 | 2910 | 0321 | +35.47 |
| 1½ | 53.4113 | 4180 | 0398 | 44.37 | | | | | |

Weighted mean +42.60
 V_a -15.39
 V_d +.23
 Curvature - .28

Radial velocity. +27.2

 β ORIONIS 2127.1909. Jan. 12.
G. M. T. 12^h 18^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 54.7144 | | | | 2 | 53.0960 | | | |
| 2 | 54.0082 | | | | 2 | 45.2991 | | | |
| 2½ | 53.9787 | 9765 | 0333 | +37.15 | 2 | 45.3000 | 2945 | 0356 | +39.34 |
| 1½ | 53.4291 | 4224 | 0442 | 49.28 | | | | | |

Weighted mean +40.91
 V_a -15.39
 V_d +.23
 Curvature - .28

Radial velocity. +25.5

 β ORIONIS 2128.1909. Jan. 13.
G. M. T. 15^h 36^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 54.7086 | | | | 2 | 53.0920 | | | |
| 2 | 54.0031 | | | | 2 | 45.2968 | | | |
| 2 | 53.9775 | 9790 | 0358 | +41.41 | 2 | 45.3012 | 2980 | 0391 | +41.06 |
| 2 | 53.4281 | 4275 | 0493 | 56.65 | | | | | |

Weighted mean +46.37
 V_a -15.81
 V_d -.09
 Curvature -.28

Radial velocity ... +30.2

SESSIONAL PAPER No. 25a

 β ORIONIS 2129.1909. Jan. 13.
G. M. T. 15^h 41^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7082 | ..... | ..... | ..... | 2 | 53.0803 | ..... | ..... | ..... |
| 2 | 54.0002 | ..... | ..... | ..... | 2 | 45.2978 | ..... | ..... | ..... |
| 2 | 53.9730 | .9748 | .0316 | +36.54 | 1½ | 45.2852 | .2810 | .0221 | +23.20 |
| 1 | 53.4061 | .4068 | .0286 | 32.86 | | | | | |

Weighted mean..... +31.90

 V_a -15.81 V_d 09

Curvature28

Radial velocity +15.7

 β ORIONIS 2130.1909. Jan. 13.
G. M. T. 15^h 46^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.6985 | ..... | ..... | ..... | 2 | 53.0813 | ..... | ..... | ..... |
| 2 | 53.9934 | ..... | ..... | ..... | 2 | 45.2892 | ..... | ..... | ..... |
| 2 | 53.9782 | .9889 | .0448 | +51.82 | 2 | 45.2940 | .2984 | .0395 | +41.48 |
| 1 | 53.4029 | .4115 | .0333 | 38.26 | | | | | |

Weighted mean..... +44.97

 V_a -15.81 V_d 09

Curvature28

Radial velocity..... -28.8

 β ORIONIS 2142.1909. Jan. 15.
G. M. T. 15^h 11^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 54.7058 | ..... | ..... | ..... | 2 | 53.0911 | ..... | ..... | ..... |
| 2 | 53.9996 | ..... | ..... | ..... | 2 | 45.2970 | ..... | ..... | ..... |
| 1 | 53.9752 | .9790 | .0358 | +41.40 | 2 | 45.3055 | .3021 | .0432 | +45.36 |
| 2 | 53.4083 | .4105 | .0323 | 37.14 | | | | | |

Weighted mean..... +41.28

 V_a -16.50 V_d 04

Curvature..... .28

Radial velocity..... -24.5

9-10 EDWARD VII., A. 1910

 β ORIONIS 2141.1909. Jan. 15.
G. M. T. 14^h 51^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in Rev ^{ms} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 56.6150 | | | | 2 | 53.0735 | | | |
| 2 | 54.7025 | | | | 2 | 45.2772 | | | |
| 2 | 53.9628 | .9778 | .0346 | -40.02 | 3 | 45.2777 | .2940 | .0351 | -36.86 |
| 1 | 53.3821 | .3975 | .0193 | 22.18 | | | | | |

Weighted mean..... +35.47

 V_d 16.50 V_d04

Curvature..... .28

Radial velocity..... 18.6

 β ORIONIS 2143.1909. Jan. 15.
G. M. T. 15^h 15^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54.7162 | | | | 2 | 53.0946 | | | |
| 2 | 54.0069 | | | | 2 | 45.2937 | | | |
| 3 | 53.9895 | .9814 | .0412 | +47.65 | 2 | 45.3062 | .3061 | .0472 | -49.56 |
| 1½ | 53.4092 | .4040 | .0258 | 29.65 | | | | | |

Weighted mean..... +44.08

 V_d 16.50 V_d04

Curvature..... .28

Radial velocity..... -27.2

 β ORIONIS 2144.1909. Jan. 15.
G. M. T. 15^h 19^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ms} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54.7063 | | | | 2 | 53.0782 | | | |
| 2 | 53.9945 | | | | 2 | 45.2864 | | | |
| 1 | 53.9672 | .9750 | .0318 | -36.78 | 2 | 45.2847 | .2920 | .0351 | +34.76 |
| 1 | 53.4103 | .4200 | .0418 | 48.03 | | | | | |

Weighted mean..... +38.58

 V_d 16.50 V_d04

Curvature..... .28

Radial velocity..... +21.8

SESSIONAL PAPER No. 25a

 β ORIONIS 2151.1909. Jan. 16.
G. M. T. 12^h 25^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.6926 | ..... | ..... | ..... | 2 | 53.0657 | ..... | ..... | ..... |
| 2 | 53.9756 | ..... | ..... | ..... | 2 | 45.2780 | ..... | ..... | ..... |
| 1 | 53.9598 | .9850 | .0418 | + 48.25 | 3 | 45.2970 | .3130 | .0541 | - 56.61 |
| 2 | 53.3854 | .4104 | .0322 | 36.00 | | | | | |

Weighted mean..... + 48.35

 V_a - 16.82 V_d + 13

Curvature..... .28

Radial velocity..... + 31.4

 β ORIONIS 2152.1909. Jan. 16.
G. M. T. 12^h 36^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.6990 | ..... | ..... | ..... | 2 | 53.0859 | ..... | ..... | ..... |
| 2 | 53.9982 | ..... | ..... | ..... | 2 | 45.2919 | ..... | ..... | ..... |
| 2 | 53.9738 | .9820 | .0388 | + 44.78 | 2 | 45.2978 | .2965 | .0406 | + 42.63 |
| 1 | 53.4168 | .4210 | .0428 | 48.18 | | | | | |

Weighted mean..... + 44.60

 V_a - 16.82 V_d + 13

Curvature..... - .28

Radial velocity..... - 27.6

 β ORIONIS 2153.1909. Jan. 16.
G. M. T. 12^h 44^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7003 | ..... | ..... | ..... | 2 | 53.0787 | ..... | ..... | ..... |
| 2 | 54.0022 | ..... | ..... | ..... | 2 | 45.2970 | ..... | ..... | ..... |
| 2 | 53.9786 | .9886 | .0454 | - 52.51 | 3 | 45.3131 | .3100 | .0511 | - 53.66 |
| 1 | 53.4072 | .4160 | .0378 | 43.44 | | | | | |

Weighted mean..... - 51.38

 V_a - 16.82 V_d - 13

Curvature..... - .28

Radial velocity..... + 34.4

9-10 EDWARD VII., A. 1910

 β ORIONIS 2154.1909. Jan. 16.
G. M. T. 12^h 52^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 56.6114 | ..... | ..... | ..... | 2 | 53.0724 | ..... | ..... | ..... |
| 2 | 54.6911 | ..... | ..... | ..... | 2 | 45.2845 | ..... | ..... | ..... |
| 2 | 53.9844 | .0025 | .0593 | +68.59 | 2 | 45.3008 | .3100 | .0511 | +53.66 |
| 1½ | 53.4059 | .4220 | .0438 | 49.23 | | | | | |

Weighted mean..... + 57.88

 V_a -16.82 V_d + .13

Curvature..... - .28

Radial velocity..... + 40.9

 β ORIONIS 2155.1909. Jan. 16.
G. M. T. 12^h 59^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 56.6278 | ..... | ..... | ..... | 2 | 53.4202 | .4220 | .0438 | 49.23 |
| 2 | 54.7078 | ..... | ..... | ..... | 2 | 53.0850 | ..... | ..... | ..... |
| 2 | 54.0014 | ..... | ..... | ..... | 2 | 45.2940 | ..... | ..... | ..... |
| 2 | 53.9853 | .9875 | .0443 | +51.03 | 2 | 45.3136 | .3130 | .0541 | +53.66 |

Weighted mean..... + 51.01

 V_a -16.82 V_d + .13

Curvature..... .28

Radial velocity..... + 33.0

 β ORIONIS 2156.1909. Jan. 16.
G. M. T. 13^h 12^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7101 | ..... | ..... | ..... | 2 | 53.0934 | ..... | ..... | ..... |
| 2 | 54.0028 | ..... | ..... | ..... | 2 | 45.3008 | ..... | ..... | ..... |
| 4 | 53.9856 | .9845 | .0413 | +47.77 | 3 | 45.3214 | .3140 | .0551 | +58.91 |
| 2 | 53.4297 | .4250 | .0468 | 53.78 | | | | | |

Weighted mean..... + 52.82

 V_a -16.82 V_d + .13

Curvature..... - .28

Radial velocity..... + 35.8

SESSIONAL PAPER No. 25a

 β ORIONIS 2157.1909. Jan. 17.
G. M. T. 13^h 48^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.6992 | | | | 2 | 53.6902 | | | |
| 2 | 53.9936 | | | | 2 | 45.2896 | | | |
| 3 | 53.9741 | | .0118 | +43.34 | 2 | 45.3062 | .3102 | .0513 | +53.87 |
| 1 | 53.3965 | | .0273 | 31.37 | | | | | |

Weighted mean..... + 47.35

 V_a -17.17 V_d + .05

Curvature..... .28

Radial velocity + 29.7

 β ORIONIS 2158.1909. Jan. 17.
G. M. T. 13^h 56^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.6898 | | | | 2 | 53.0742 | | | |
| 2 | 53.9898 | | | | 2 | 45.2874 | | | |
| 2 | 53.9655 | .9835 | .0403 | +46.61 | 2 | 45.2947 | .3010 | .0421 | +44.21 |
| 2 | 53.3969 | .4130 | .0348 | 39.99 | | | | | |

Weighted mean..... +43.60

 V_a -17.17 V_d + .05

Curvature..... .28

Radial velocity..... + 26.2

 β ORIONIS 2161.1909. Jan. 18.
G. M. T. 12^h 41^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----------------|-------------------------|--------------------------------|---|-----------|-----------------|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7073 | | | | 2 | 53.0908 | | | |
| 2 | 53.9976 | | | | 2 | 45.2916 | | | |
| 2 | 53.9851 | .9880 | .0448 | +51.81 | 2 $\frac{1}{2}$ | 45.3141 | .3160 | .0571 | +59.96 |
| 1 $\frac{1}{2}$ | 53.4217 | .4220 | .0438 | 50.37 | | | | | |

Weighted mean..... +54.84

 V_a -17.17 V_d + .05

Curvature..... .28

Radial velocity..... +37.1

9-10 EDWARD VII., A. 1910

 β ORIONIS 2162.1909. Jan. 18.
G. M. T. 12^h 46^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7174 | ..... | ..... | ..... | 2 | 53.0879 | ..... | ..... | ..... |
| 2 | 54.0111 | ..... | ..... | ..... | 2 | 45.3097 | ..... | ..... | ..... |
| 3 | 53.9987 | .9900 | .0468 | +54.12 | 2 | 45.3267 | .3105 | .0516 | +54.19 |
| 2 | 53.4185 | .4098 | .0316 | 36.34 | | | | | |

Weighted mean +49.06
 V_a -17.17
 V_d + .05
Curvature - .28
Radial velocity +31.3

 β ORIONIS 2163.1909. Jan. 18.
G. M. T. 12^h 51^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7067 | ..... | ..... | ..... | 2 | 53.0858 | ..... | ..... | ..... |
| 2 | 53.9965 | ..... | ..... | ..... | 2 | 45.2994 | ..... | ..... | ..... |
| 3 | 53.9771 | .9820 | .0388 | +44.87 | 2 | 45.3122 | .3064 | .0475 | +49.88 |
| 1 | 53.4107 | .4147 | .0365 | 41.94 | | | | | |

Weighted mean +46.05
 V_a -17.51
 V_d + .08
Curvature - .28
Radial velocity +28.3

 β ORIONIS 2164.1909. Jan. 18.
G. M. T. 13^h 06^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7077 | ..... | ..... | ..... | 2 | 53.0867 | ..... | ..... | ..... |
| 2 | 53.9990 | ..... | ..... | ..... | 2 | 45.2983 | ..... | ..... | ..... |
| 2 | 53.9926 | .9954 | .0521 | +59.16 | 3 | 45.3107 | .3060 | .0471 | +49.46 |
| 2 | 53.4235 | .4261 | .0479 | 54.04 | | | | | |

Weighted mean +53.54
 V_a -17.57
 V_d + .08
Curvature - .28
Radial velocity +35.8

SESSIONAL PAPER No. 25a

 β ORIONIS 2165.1909. Jan. 18.
G. M. T. 13^h 10^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 54.7128 | | | | 2 | 53.0967 | | | |
| 2 | 54.0073 | | | | 2 | 45.3114 | | | |
| 3 | 53.9885 | .9830 | .0398 | +45.93 | 2 | 45.3277 | .3100 | .0571 | +53.66 |
| 1 | 53.4284 | .4215 | .0433 | 48.66 | | | | | |

Weighted mean +48.96
 V_a -17.57
 V_d + .08
Curvature28
Radial velocity +31.2

 β ORIONIS 2166.1909. Jan. 18.
G. M. T. 13^h 14^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----------------|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 54.7106 | | | | 2 | 53.0896 | | | |
| 2 | 53.9998 | | | | 2 | 45.3060 | | | |
| 1 $\frac{1}{2}$ | 53.9796 | .9805 | .0373 | +43.14 | 3 | 45.3184 | .3065 | .0471 | +49.46 |
| 1 $\frac{1}{2}$ | 53.4221 | .4225 | .0443 | 50.95 | | | | | |

Weighted mean +48.25
 V_a -17.57
 V_d + .08
Curvature28
Radial velocity -30.5

 β ORIONIS 2177.1909. Jan. 26.
G. M. T. 10^h 36^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 54.7218 | | | | 2 | 53.0968 | | | |
| 2 | 54.0098 | | | | 2 | 45.2904 | | | |
| 2 | 53.9936 | .9856 | .0424 | +49.04 | 2 | 45.2922 | .2954 | .0365 | +38.33 |
| 1 | 53.4276 | .4200 | .0418 | 48.03 | | | | | |

Weighted mean +44.55
 V_a -19.95
 V_d + .22
Curvature28
Radial velocity +24.6

9-10 EDWARD VII., A. 1910

 β ORIONIS 2178.1909. Jan. 26.
G. M. T. 10^h 51^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7527 | ..... | ..... | ..... | 2 | 53 1294 | ..... | ..... | ..... |
| 2 | 54 0433 | ..... | ..... | ..... | 2 | 45 3207 | ..... | ..... | ..... |
| 3 | 54 0181 | 9706 | 0334 | +38.63 | 1 | 45 3132 | 2861 | 0272 | +28.56 |
| 1½ | 52 4554 | 4150 | 0368 | 42.29 | | | | | |

Weighted mean..... +37.80
 V_a -19.95
 V_d + .22
 Curvature..... - .28
 Radial velocity..... +17.8

 β ORIONIS 2179.1909. Jan. 26.
G. M. T. 10^h 56^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7468 | ..... | ..... | ..... | 2 | 53 1221 | ..... | ..... | ..... |
| 2 | 54 0423 | ..... | ..... | ..... | 2 | 45 3160 | ..... | ..... | ..... |
| 2 | 54 0140 | 53 9780 | 0348 | +40.25 | 2 | 45 3215 | 2890 | 0401 | +42.11 |
| 1½ | 53 4594 | 4260 | 0478 | 54.93 | | | | | |

Weighted mean..... +44.93
 V_a -19.95
 V_d + .22
 Curvature..... - .28
 Radial velocity..... +24.9

 β ORIONIS 2180.1909. Jan. 26.
G. M. T. 11^h 01^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7250 | ..... | ..... | ..... | 2 | 53 1036 | ..... | ..... | ..... |
| 2 | 54 0212 | ..... | ..... | ..... | 2 | 45 2950 | ..... | ..... | ..... |
| 2½ | 53 9634 | 9770 | 0338 | +39.09 | 1½ | 45 3008 | 2994 | 0405 | +42.53 |
| 1 | 53 4420 | 4270 | 0488 | 56.08 | | | | | |

Weighted mean..... +43.52
 V_a -19.95
 V_d + .22
 Curvature..... - .28
 Radial velocity..... +23.5

SESSIONAL PAPER No. 25a

1909, Jan. 26.
G. M. T. 11^h 11^m β ORIONIS 2181.Observed by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------|-----------|-----|-------------------|--------------------------|---------------------------|-----------|
| 2 | 54° 7250 | ..... | ..... | ..... | 2 | 53° 0986 | ..... | ..... | ..... |
| 2 | 54° 0155 | ..... | ..... | ..... | 2 | 45° 2908 | ..... | ..... | ..... |
| 3 | 53° 9908 | 9780 | 0358 | +41 40 | 1½ | 45° 3051 | 2990 | 0401 | +42 11 |
| 1 | 53° 4287 | 4180 | 0398 | 45 73 | | | | | |

Weighted mean..... +42 38
 V_d -19 95
 V_d 22
 Curvature..... 28
 Radial velocity..... 22 4

 γ ORIONIS 2182.1909, Jan. 26.
G. M. T. 11^h 16^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------|-----------|-----|-------------------|--------------------------|---------------------------|-----------|
| 2 | 54° 7440 | ..... | ..... | ..... | 2 | 53° 1178 | ..... | ..... | ..... |
| 2 | 54° 0407 | ..... | ..... | ..... | 2 | 45° 3060 | ..... | ..... | ..... |
| 2 | 54° 0083 | 9770 | 0338 | +39 09 | 2 | 45° 3066 | 2912 | 0323 | +33 92 |
| ½ | 53° 4372 | 4080 | 0298 | 34 24 | | | | | |

Weighted mean..... +36 25
 V_d -19 95
 V_d + 22
 Curvature..... 28
 Radial velocity..... +16 2

 δ ORIONIS 2183.1909, Jan. 26.
G. M. T. 11^h 21^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------|-----------|-----|-------------------|--------------------------|---------------------------|-----------|
| 2 | 54° 7394 | ..... | ..... | ..... | 2 | 53° 1107 | ..... | ..... | ..... |
| 2 | 54° 0262 | ..... | ..... | ..... | 2 | 45° 2972 | ..... | ..... | ..... |
| 3 | 54° 0003 | 9760 | 0328 | +37 93 | 2 | 45° 3035 | 3000 | 0411 | +43 16 |
| ½ | 53° 4399 | 4175 | 0393 | 45 14 | | | | | |

Weighted mean..... +40 49
 V_d -19 95
 V_d + 22
 Curvature..... 28
 Radial velocity..... +20 5

9-10 EDWARD VII., A. 1910

 β ORIONIS 2184.1909. Jan. 28.
G. M. T. 11^h 21^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7322 | | | | 2 | 53° 1120 | | | |
| 2 | 54° 0224 | | | | 2 | 45° 3111 | | | |
| 3 | 54° 0907 | 9800 | 0363 | +42° 56 | 2 | 45° 3122 | 2947 | 0358 | +37° 59 |
| 1 | 53° 4160 | 3940 | 0158 | 18° 16 | | | | | |

Weighted mean. +36° 84

 V_a -20° 51 V_d + 21

Curvature. - 28

Radial velocity. -16° 3

 γ ORIONIS 2185.1909. Jan. 28.
G. M. T. 11^h 25^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7073 | | | | 2 | 53° 0869 | | | |
| 2 | 53° 9993 | | | | 2 | 45° 2864 | | | |
| 2 | 53° 9800 | 9830 | 0368 | +46° 03 | 2 | 45° 2882 | 2954 | 0365 | +38° 33 |
| 1 | 53° 4194 | 4220 | 0438 | 50° 33 | | | | | |

Weighted mean. -43° 81

 V_a -20° 51 V_d + 21

Curvature. - 29

Radial velocity. +23° 2

 β ORIONIS 2186.1909. Jan. 28.
G. M. T. 11^h 25^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7073 | | | | 2 | 53° 0851 | | | |
| 2 | 54° 0002 | | | | 2 | 45° 2893 | | | |
| 2 | 53° 9697 | 9735 | 0303 | +35° 04 | 2 | 45° 2888 | 2930 | 0341 | +35° 81 |
| 1 | 53° 4020 | 4060 | 0278 | 31° 54 | | | | | |

Weighted mean. +34° 73

 V_a -20° 51 V_d + 21

Curvature. - 28

Radial velocity. +14° 2

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 β ORIONIS 2187.1909. Jan. 28.
G. M. T. 11^h 41^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7131 | | | | 2 | 53.6944 | | | |
| 2 | 54.6015 | | | | 2 | 45.2911 | | | |
| 2 | 53.9731 | .9705 | .0273 | +31.57 | 2 | 45.2883 | .2908 | .0318 | +33.39 |
| 1½ | 53.4183 | .4140 | .0358 | 41.14 | | | | | |

Weighted mean..... +34.84
 V_a -20.51
 V_d 21
 Curvature..... .28

Radial velocity..... +14.3

 β ORIONIS 2188.1909. Jan. 28.
G. M. T. 11^h 44^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7128 | | | | 2 | 53.6905 | | | |
| 2 | 54.0033 | | | | 2 | 45.2924 | | | |
| 2 | 53.9628 | .9614 | .0182 | +21.05 | 1½ | 45.2857 | .2869 | .0280 | +29.40 |
| 1½ | 53.4200 | .4187 | .0405 | 46.54 | | | | | |

Weighted mean..... +31.20
 V_a -20.51
 V_d + 21
 Curvature..... .28

Radial velocity..... +10.6

 β ORIONIS 2189.1909. Jan. 28.
G. M. T. 11^h 47^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7175 | | | | 2 | 53.1003 | | | |
| 2 | 54.0085 | | | | 2 | 45.2987 | | | |
| 2 | 53.9802 | .9790 | .0298 | +34.46 | 1½ | 43.2937 | .2886 | .0397 | +41.69 |
| 1½ | 53.4243 | .4150 | .0368 | 42.29 | | | | | |

Weighted mean..... +38.98
 V_a -20.51
 V_d + 21
 Curvature..... .28

Radial velocity..... +18.4

9-10 EDWARD VII., A. 1910

 β ORIONIS 2195.1909. Jan. 29.
G. M. T. 12^h 53^m.Observed by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7212 | ..... | ..... | ..... | 2 | 53.1014 | ..... | ..... | ..... |
| 2 | 54.0176 | ..... | ..... | ..... | 2 | 45.2906 | ..... | ..... | ..... |
| 2 | 53.9840 | 9710 | 0278 | +32.15 | 1 | 45.2923 | 2958 | 0309 | +38.75 |
| 1 | 53.4261 | 4135 | 0353 | 40.56 | | | | | |

Weighted mean..... +35.90

 V_a -20.79 V_d +.05

Curvature..... .28

Radial velocity..... +14.9

 β ORIONIS 2196.1909. Jan. 29.
G. M. T. 12^h 57^m.Observed by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7168 | ..... | ..... | ..... | 2 | 53.0946 | ..... | ..... | ..... |
| 2 | 54.0073 | ..... | ..... | ..... | 2 | 45.2894 | ..... | ..... | ..... |
| 3 | 53.9817 | 9762 | 0330 | +38.16 | 1½ | 45.2877 | 2919 | 0330 | +34.65 |
| ½ | 53.4324 | 4270 | 0488 | 56.08 | | | | | |

Weighted mean..... +38.90

 V_a -20.79 V_d +.05

Curvature..... .28

Radial velocity..... +17.9

 β ORIONIS 2197.1909. Jan. 29.
G. M. T. 13^h 01^m.Observed by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7222 | ..... | ..... | ..... | 2 | 53.0081 | ..... | ..... | ..... |
| 2 | 54.0097 | ..... | ..... | ..... | 2 | 45.2919 | ..... | ..... | ..... |
| 2 | 53.9881 | 9790 | 0358 | +41.40 | 1 | 45.3034 | 3050 | 0461 | +48.41 |
| ½ | 53.4480 | 4390 | 0608 | 69.87 | | | | | |

Weighted mean..... +47.47

 V_a -20.79 V_d +.05

Curvature..... .28

Radial velocity..... +26.4

SESSIONAL PAPER No. 25a

 β ORIONIS 2198.1909. Jan. 29.
G. M. T. 13^h 05^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 54° 7170 | ..... | ..... | ..... | 2 | 53° 0924 | ..... | ..... | ..... |
| 2 | 54° 0100 | ..... | ..... | ..... | 2 | 45° 2871 | ..... | ..... | ..... |
| 2 | 53° 9896 | 9840 | 0408 | +47° 18 | 2 | 45° 2927 | 2992 | 0403 | +42° 32 |
| 1½ | 53° 4164 | 4120 | 0338 | 38° 84 | | | | | |

Weighted mean..... + 43° 14
 V_a - 20° 79
 V_d 65
 Curvature..... - 28

Radial velocity..... +22.1

 β ORIONIS 2201.1909. Jan. 30.
G. M. T. 12^h 29^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 54° 7150 | ..... | ..... | ..... | 2 | 53° 0957 | ..... | ..... | ..... |
| 2 | 54° 0093 | ..... | ..... | ..... | 2 | 45° 2906 | ..... | ..... | ..... |
| 3 | 53° 9791 | 9730 | 0298 | +34° 46 | 2 | 45° 2884 | 2914 | 0325 | +34° 13 |
| 1 | 53° 4193 | 4130 | 0348 | 39° 99 | | | | | |

Weighted mean..... + 35° 27
 V_a - 21° 05
 V_d + 06
 Curvature..... - 28

Radial velocity..... +14.0

 β ORIONIS 2202.1909. Jan. 30.
G. M. T. 12^h 41^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 54° 7150 | ..... | ..... | ..... | 2 | 53° 5937 | ..... | ..... | ..... |
| 2 | 54° 0022 | ..... | ..... | ..... | 2 | 45° 2878 | ..... | ..... | ..... |
| 1½ | 53° 9764 | 9710 | 0268 | +30° 99 | 2 | 45° 2963 | 3020 | 0431 | +45° 26 |
| 1 | 53° 4141 | 4100 | 0318 | 36° 54 | | | | | |

Weighted mean..... + 38° 57
 V_a - 21° 05
 V_d + 06
 Curvature..... - 28

Radial velocity..... + 17.3

9-10 EDWARD VII., A. 1910

 β ORIONIS 2203.1909. Jan. 30.
G. M. T. 12^h 45^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|---------------|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7115 | | | | 2 | 53° 0902 | | | |
| 2 | 53° 9970 | | | | 2 | 45° 2808 | | | |
| 1 | 53° 9941 | 9950 | 0518 | +59° 91 | 2 | 45° 2822 | 2950 | 0361 | +37° 91 |
| $\frac{1}{2}$ | 53° 4224 | 4240 | 0458 | 52° 63 | | | | | |

Weighted mean..... +46° 29
 V_a -21° 05
 V_d + 06
 Curvature..... - 28
 Radial velocity..... +25° 0

 β ORIONIS 2204.1909. Jan. 30.
G. M. T. 12^h 48^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7152 | | | | 2 | 53° 0917 | | | |
| 2 | 54° 0046 | | | | 2 | 45° 2833 | | | |
| 1 | 53° 9739 | 9712 | 0290 | -32° 38 | 2 | 45° 2869 | 2972 | 0383 | +40° 22 |
| 1 | 53° 4059 | 4034 | 0252 | 28° 96 | | | | | |

Weighted mean..... -35° 45
 V_a -21° 05
 V_d + 06
 Curvature..... - 28
 Radial velocity..... -14° 2

 β ORIONIS 2205.1909. Jan. 30.
G. M. T. 13^h 47^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|----------------|-------------------------|--------------------------------|---|-----------|----------------|-------------------------|--------------------------------|---|-----------|
| 2 | 63° 3385 | | | | 2 | 58° 7894 | | | |
| 2 | 61° 3585 | | | | 2 | 36° 1737 | | | |
| 3 | 61° 2878 | 2744 | 0939 | +38° 82 | $1\frac{1}{2}$ | 36° 1979 | 2180 | 1275 | +44° 83 |
| $1\frac{1}{2}$ | 59° 7215 | 7140 | 1175 | 48° 07 | | | | | |

Weighted mean..... +42° 63
 V_a -21° 05
 V_d + 06
 Curvature..... - 28
 Radial velocity..... +21° 0

SESSIONAL PAPER No. 25a

 β ORIONIS 2206.1900, Jan. 30.
G. M. T. 16^h 04^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3436 | | | | 2 | 58.7994 | | | |
| 2 | 61.3644 | | | | 2 | 36.1900 | | | |
| 2 | 61.3040 | 2850 | 1045 | +43.20 | 1½ | 36.2046 | 2088 | 1173 | +41.24 |
| 1½ | 59.7313 | 7150 | 1185 | 48.48 | | | | | |

Weighted mean..... +44.20

 V_d -21.10 V_d -24

Curvature..... -28

Radial velocity..... +22.6

 β ORIONIS 2207.1900, Jan. 30.
G. M. T. 16^h 24^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3410 | | | | 2 | 58.7983 | | | |
| 2 | 61.3604 | | | | 2 | 36.1943 | | | |
| 3 | 61.3037 | 2880 | 1075 | +44.44 | 2 | 36.2027 | 2026 | 1121 | +39.41 |
| 1½ | 59.7308 | 7160 | 1195 | 48.89 | | | | | |

Weighted mean..... +43.92

 V_d -21.10 V_d -24

Curvature..... -28

Radial velocity..... +22.3

 β ORIONIS 2211.1900, Jan. 31.
G. M. T. 17^h 16^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} . | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7191 | | | | 2 | 53.0951 | | | |
| 2 | 54.0063 | | | | 2 | 45.2834 | | | |
| 2 | 53.9870 | 9800 | 0368 | +42.56 | 2 | 45.2806 | 2908 | 0319 | +33.50 |
| 1 | 53.4342 | 4275 | 0493 | 56.65 | | | | | |

Weighted mean..... +41.75

 V_d -21.33 V_d -31

Curvature..... -28

Radial velocity..... +19.8

9-10 EDWARD VII., A. 1910

 β ORIONIS 2212.1909. Jan. 31.
G. M. T. 17^h 20^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7084 | ..... | ..... | ..... | 2 | 53.0894 | ..... | ..... | ..... |
| 2 | 54.0012 | ..... | ..... | ..... | 2 | 45.2894 | ..... | ..... | ..... |
| 2 | 53.9833 | 9835 | .0403 | -46.61 | 1½ | 45.2886 | 2928 | .0339 | -35.60 |
| 1 | 53.4274 | 4273 | 0491 | 56.42 | | | | | |

Weighted mean..... +45.12

 V_a -21.33 V_d31

Curvature..... .28

Radial velocity..... +23.2

 β ORIONIS 2213.1909. Jan. 31.
G. M. T. 17^h 24^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7118 | ..... | ..... | ..... | 2 | 53.0904 | ..... | ..... | ..... |
| 2 | 54.0115 | ..... | ..... | ..... | 2 | 45.2938 | ..... | ..... | ..... |
| 2 | 53.9797 | 9737 | .0305 | +35.27 | 2 | 45.2925 | 2923 | .0334 | -35.07 |
| 1 | 53.4258 | 4190 | 0403 | 46.88 | | | | | |

Weighted mean..... -37.91

 V_a -21.33 V_d31

Curvature..... .28

Radial velocity..... +16.0

 β ORIONIS 2214.1909. Jan. 31.
G. M. T. 17^h 29^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7065 | ..... | ..... | ..... | 2 | 53.0873 | ..... | ..... | ..... |
| 2 | 53.9988 | ..... | ..... | ..... | 2 | 45.2835 | ..... | ..... | ..... |
| 1½ | 53.9803 | 9840 | .0408 | +47.18 | 2 | 45.2763 | 2864 | .0275 | +28.88 |
| 1 | 53.4149 | 4174 | .0392 | 45.04 | | | | | |

Weighted mean..... +38.57

 V_a -21.33 V_d31

Curvature..... .28

Radial velocity..... +16.6

SESSIONAL PAPER No. 25a

 β ORIONIS 2215.1909. Feb. 2.
G. M. T. 11^h 14^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7008 | | | | 2 | 53 0885 | | | |
| 2 | 54 0638 | | | | 2 | 45 2951 | | | |
| 2 | 53 9791 | 9803 | 0371 | +42 90 | 2 | 45 3072 | 3067 | 0478 | +50 19 |
| 2 | 53 4182 | 4192 | 0410 | 47 11 | | | | | |

Weighted mean..... +46 73

 V_a -21 79 V_d + 14

Curvature..... - 28

Radial velocity..... +24 8

 β ORIONIS 2216.1909. Feb. 2.
G. M. T. 11^h 23^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7162 | | | | 2 | 53 0940 | | | |
| 2 | 54 0091 | | | | 2 | 45 3030 | | | |
| 2 | 53 9864 | 9810 | 0378 | +43 72 | 2 | 45 3047 | 2953 | 0364 | +38 22 |
| 2 | 53 4299 | 4250 | 0468 | 53 78 | | | | | |

Weighted mean..... +45 02

 V_a -21 79 V_d + 14

Curvature..... - 28

Radial velocity..... +23 1

 β ORIONIS 2217.1909. Feb. 2.
G. M. T. 11^h 26^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7143 | | | | 2 | 53 0916 | | | |
| 1 | 54 0053 | | | | 2 | 45 2940 | | | |
| 3 | 53 9820 | 9790 | 0358 | +41 40 | 2 | 45 3032 | 3028 | 0439 | +46 10 |
| 1 | 53 4303 | 4277 | 0495 | 56 88 | | | | | |

Weighted mean..... +45 35

 V_a -21 79 V_d + 14

Curvature..... - 28

Radial velocity..... +23 6

9-10 EDWARD VII., A. 1910

 β ORIONIS 2218.1909. Feb. 2.
G. M. T. 11^h 29^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7101 | | | | 2 | 53° 0910 | | | |
| 2 | 54° 0023 | | | | 2 | 45° 2961 | | | |
| 2 | 53° 9848 | 9845 | 0413 | +47.76 | 2 | 45° 3020 | 2995 | 0406 | +42.63 |
| 1 | 53° 4172 | 4160 | 0378 | 43.44 | | | | | |

Weighted mean..... +44.44

 V_a -21.97 V_d + 14

Curvature..... - 28

Radial velocity..... +22.5

 β ORIONIS 2219.1909. Feb. 2.
G. M. T. 11^h 41^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----------------|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7180 | | | | 2 | 53° 0937 | | | |
| 2 | 54° 0106 | | | | 2 | 45° 3002 | | | |
| 3 | 53° 9813 | 9740 | 0308 | +35.62 | 2 | 45° 3032 | 2966 | 0377 | +39.59 |
| 1 $\frac{1}{2}$ | 53° 4213 | 4150 | 0368 | 42.29 | | | | | |

Weighted mean..... +38.39

 V_a -21.79 V_d + 14

Curvature..... - 28

Radial velocity..... +16.5

 β ORIONIS 2220.1909. Feb. 2.
G. M. T. 11^h 45^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54° 7143 | | | | 2 | 53° 0952 | | | |
| 2 | 54° 0073 | | | | 2 | 45° 2903 | | | |
| 3 | 53° 9847 | 9800 | 0368 | +42.56 | 2 | 45° 2967 | 3000 | 0411 | +43.16 |
| 1 | 53° 4305 | 4250 | 0468 | 53.78 | | | | | |

Weighted mean..... +44.63

 V_a -21.79 V_d + 14

Curvature..... - 28

Radial velocity..... +22.7

SESSIONAL PAPER No. 25a

 β ORIONIS 2220*1909, Feb. 2.
G. M. T. 11^h 45^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7580 | ..... | ..... | ..... | 3 | 53.1366 | ..... | ..... | ..... |
| 2 | 54.0249 | .9779 | .0347 | +40.03 | 2 | 45.3355 | 3006 | .0417 | +43.78 |
| 1½ | 53.4623 | .4151 | .0369 | 42.40 | 3 | 45.3235 | ..... | ..... | ..... |

Weighted mean +42.04

 V_a -21.79 V_d -14

Curvature... -28

* Check.

Radial velocity. +20.2

 β ORIONIS 2236.1909, Feb. 6.
G. M. T. 12^h 29^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7129 | ..... | ..... | ..... | 2 | 53.0895 | ..... | ..... | ..... |
| 2 | 54.0040 | ..... | ..... | ..... | 2 | 45.2921 | ..... | ..... | ..... |
| 2 | 53.9767 | .9750 | .0318 | +36.78 | 3 | 45.2985 | 3000 | .0411 | +43.16 |
| 1 | 53.4149 | .4143 | .0361 | 41.48 | | | | | |

Weighted mean +40.75

 V_a -22.07 V_d -24

Curvature... -28

Radial velocity. -18.2

 β ORIONIS 2239.1909, Feb. 6.
G. M. T. 12^h 50^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7144 | ..... | ..... | ..... | 2 | 53.0925 | ..... | ..... | ..... |
| 2 | 54.0085 | ..... | ..... | ..... | 2 | 45.2967 | ..... | ..... | ..... |
| 2 | 53.9843 | .9810 | .0378 | -43.72 | 2 | 45.3043 | 3012 | .0423 | -44.42 |
| 1½ | 53.4083 | .4052 | .0270 | 31.03 | | | | | |

Weighted mean +42.62

 V_a -22.07 V_d -24

Curvature... -28

Radial velocity. +20.0

9-10 EDWARD VII., A. 1910

1909. Feb. 6.
G. M. T. 12^h 52^m β ORIONIS 2240.Observed by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54 7160 | ..... | ..... | ..... | 2 | 53 0936 | ..... | ..... | ..... |
| 2 | 54 0066 | ..... | ..... | ..... | 2 | 45 2951 | ..... | ..... | ..... |
| 2 | 53 9845 | 9800 | 0363 | +42 56 | 1 | 45 2950 | 2935 | 0346 | +36 33 |
| 2 | 53 4254 | 4210 | 0428 | 49 18 | | | | | |

Weighted mean..... +43 96

 V_a -22 07 V_d -24

Curvature..... -28

Radial velocity..... +21 0

 β ORIONIS 2241.1909. Feb. 6.
G. M. T. 16^h 12^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63 3172 | ..... | ..... | ..... | 2 | 58 7726 | ..... | ..... | ..... |
| 2 | 61 3357 | ..... | ..... | ..... | 2 | 36 1652 | ..... | ..... | ..... |
| 2 | 61 2768 | 2858 | 1053 | +43 53 | 1½ | 36 1710 | 2000 | 1095 | +38 00 |
| 1½ | 59 7176 | 7280 | 1315 | 54 10 | | | | | |

Weighted mean..... +45 19

 V_a -22 73 V_d -30

Curvature..... -28

Radial velocity..... +21 9

 β ORIONIS 2242.1909. Feb. 6.
G. M. T. 16^h 43^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63 3249 | ..... | ..... | ..... | 2 | 58 7845 | ..... | ..... | ..... |
| 2 | 61 3494 | ..... | ..... | ..... | 2 | 36 1810 | ..... | ..... | ..... |
| 2 | 61 2686 | 2670 | 0865 | +35 76 | 1½ | 36 1972 | 2104 | 1199 | +42 16 |
| 1½ | 59 7224 | 7220 | 1255 | 51 34 | | | | | |

Weighted mean..... +42 36

 V_a -22 73 V_d -30

Curvature..... -28

Radial velocity..... +19 1

SESSIONAL PAPER No. 25a

 β ORIONIS 2243.1909. Feb. 7.
G. M. T. 15^h 11^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3350 | | | | 2 | 58.7918 | | | |
| 2 | 61.3619 | | | | 2 | 36.1731 | | | |
| 2 | 61.2972 | .2872 | .1065 | +44.03 | 2 | 36.1874 | .2085 | .1180 | +41.71 |
| 1½ | 59.7234 | .7150 | .1185 | 48.48 | | | | | |

Weighted mean..... +44.42
 V_a -22.93
 V_d -23
 Curvature..... -28

Radial velocity..... +21.0

 β ORIONIS 2244.1909. Feb. 7.
G. M. T. 15^h 25^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3380 | | | | 2 | 58.7900 | | | |
| 2 | 61.3554 | | | | 2 | 36.1752 | | | |
| 2 | 61.2952 | .2855 | .1650 | +43.41 | 1½ | 36.1830 | .2020 | .1115 | +39.20 |
| 1 | 59.7458 | .7388 | .1423 | 58.21 | | | | | |

Weighted mean..... +45.30
 V_a -22.93
 V_d -23
 Curvature..... -28

Radial velocity..... +21.9

 β ORIONIS 2245.1909. Feb. 7.
G. M. T. 15^h 37^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3424 | | | | 2 | 58.7988 | | | |
| 2 | 61.3620 | | | | 2 | 36.1867 | | | |
| 1½ | 61.2852 | .2692 | .0887 | +35.97 | 1 | 36.1858 | .1963 | .1058 | +37.20 |
| 1 | 59.7488 | .7338 | .1373 | 56.05 | | | | | |

Weighted mean..... +41.45
 V_a -22.93
 V_d -23
 Curvature..... -28

Radial velocity..... +18.0

9-10 EDWARD VII., A. 1910

 β ORIONIS 2249.1909, Feb. 8.
G. M. T. 13^h 32^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7050 | ..... | ..... | ..... | 2 | 53 0824 | ..... | ..... | ..... |
| 2 | 53 9998 | ..... | ..... | ..... | 2 | 45 2868 | ..... | ..... | ..... |
| 3 | 53 9795 | 9845 | 0413 | 47 76 | 2 | 45 3024 | 3092 | 0503 | +52 82 |
| 2 | 53 4276 | 4375 | 0593 | 68 14 | | | | | |

Weighted mean..... + 55 03

 V_a - 23 11 V_d - 08

Curvature..... - 28

Radial velocity..... + 31 6

 β ORIONIS 2250.1909, Feb. 8.
G. M. T. 13^h 36^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 6972 | ..... | ..... | ..... | 2 | 53 0777 | ..... | ..... | ..... |
| 2 | 53 9910 | ..... | ..... | ..... | 2 | 45 2869 | ..... | ..... | ..... |
| 2 | 53 9713 | 9835 | 0403 | -46 61 | 1½ | 45 2950 | 3027 | 0438 | +45 99 |
| 1 | 53 4184 | 4304 | 0522 | 59 98 | | | | | |

Weighted mean..... - 49 37

 V_a - 23 11 V_d - 08

Curvature..... - 28

Radial velocity..... + 25 9

 β ORIONIS 2251.1909, Feb. 8.
G. M. T. 13^h 41^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54 7049 | ..... | ..... | ..... | 2 | 53 0838 | ..... | ..... | ..... |
| 2 | 53 9982 | ..... | ..... | ..... | 2 | 45 2878 | ..... | ..... | ..... |
| 2 | 53 9698 | 9755 | 0323 | +37 35 | 1½ | 45 2914 | 2972 | 0383 | +40 22 |
| 3 | 53 4168 | 4225 | 0443 | 59 91 | | | | | |

Weighted mean..... +44 27

 V_a - 23 11 V_d - 08

Curvature..... - 28

Radial velocity..... +21 8

SESSIONAL PAPER No. 25a

 β ORIONIS 2252.1909, Feb. 8.
G. M. T. 14^h 01^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7056 | ..... | ..... | ..... | 2 | 53.0882 | ..... | ..... | ..... |
| 2 | 53.9980 | ..... | ..... | ..... | 2 | 45.2960 | ..... | ..... | ..... |
| 1½ | 53.9779 | .9815 | .0383 | -44.20 | 1½ | 45.2982 | .2958 | .0369 | +38.75 |
| ½ | 53.4076 | .4095 | .0313 | 35.97 | | | | | |

Weighted mean..... +41.05

 V_a 23.11 V_d08

Curvature..... .28

Radial velocity..... +17.6

 β ORIONIS 2253.1909, Feb. 8.
G. M. T. 14^h 05^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7217 | ..... | ..... | ..... | 2 | 53.1630 | ..... | ..... | ..... |
| 2 | 54.0110 | ..... | ..... | ..... | 2 | 45.3090 | ..... | ..... | ..... |
| 2 | 53.9862 | .9762 | .0330 | -38.16 | 2 | 45.3240 | .3086 | .0497 | +52.19 |
| 3 | 53.4354 | .4230 | .0448 | 51.48 | | | | | |

Weighted mean..... +47.88

 V_a -23.11 V_d08

Curvature..... .28

Radial velocity..... +24.1

 β ORIONIS 2254.1909, Feb. 8.
G. M. T. 14^h 06^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 54.7152 | ..... | ..... | ..... | 2 | 53.0963 | ..... | ..... | ..... |
| 2 | 54.0084 | ..... | ..... | ..... | 2 | 45.3112 | ..... | ..... | ..... |
| 2 | 53.9930 | .9860 | .0428 | -49.50 | 2 | 45.3142 | .2966 | .0377 | +39.59 |
| 1 | 53.4357 | .4265 | .0483 | 55.50 | | | | | |

Weighted mean..... +46.74

 V_a -23.11 V_d08

Curvature..... .28

Radial velocity..... +23.3

9-10 EDWARD VII., A. 1912

 β ORIONIS 2265.1909. Feb. 10.
G. M. T. 12^h 07^mObserved by W. E. HARPER.
Measured by J. S. FLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 54·6987 | | | | 2 | 53·9767 | | | |
| 2 | 53·9911 | | | | 2 | 45·2770 | | | |
| 2 | 53·9691 | ·9800 | ·0368 | +12·56 | 2 | 45·2980 | ·3146 | ·0557 | +58·49 |
| 1½ | 53·4197 | ·4310 | ·0528 | 69·67 | | | | | |

Weighted mean +53·29

 V_a -23·48 V_d +·05

Curvature -·28

Radial velocity +29·6

 β ORIONIS 2266.1909. Feb. 10.
G. M. T. 12^h 12^mObserved by W. E. HARPER.
Measured by J. S. FLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 54·7090 | | | | 2 | 53·0932 | | | |
| 2 | 54·0052 | | | | 2 | 45·2916 | | | |
| 2 | 53·9815 | ·9780 | ·0318 | +40·25 | 2 | 45·2989 | ·3009 | 0420 | +44·10 |
| 2 | 53·4312 | ·4275 | ·0493 | 56·65 | | | | | |

Weighted mean +47·00

 V_a -23·48 V_d +·05

Curvature -·28

Radial velocity +23·3

 β ORIONIS 2267.1909. Feb. 10.
G. M. T. 12^h 16^mObserved by W. E. HARPER.
Measured by J. S. FLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 54·7055 | | | | 2 | 53·0868 | | | |
| 2 | 53·9682 | | | | 2 | 45·2923 | | | |
| 2 | 53·9744 | ·9780 | ·0348 | +40·25 | 2 | 45·2994 | ·3007 | ·0418 | +43·89 |
| 1½ | 53·4070 | ·4100 | ·0318 | 36·54 | | | | | |

Weighted mean +40·56

 V_a -23·48 V_d +·05

Curvature -·28

Radial velocity +16·9

SESSIONAL PAPER No. 25a

 β ORIONIS 2268.1909. Feb. 10.
G. M. T. 12^h 21^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7108 | ..... | ..... | ..... | 2 | 53.0920 | ..... | ..... | ..... |
| 2 | 54.0029 | ..... | ..... | ..... | 2 | 45.2948 | ..... | ..... | ..... |
| 2 | 53.9702 | .9650 | .0258 | +29.84 | 2 | 45.2962 | .2950 | .0361 | +37.91 |
| 1½ | 53.4186 | .4160 | .0378 | 43.44 | | | | | |

Weighted mean +36.48
 V_a -23.48
 V_d +.05
 Curvature..... - .28

Radial velocity..... +12.8

 β ORIONIS 2269.1909. Feb. 10.
G. M. T. 12^h 33^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7094 | ..... | ..... | ..... | 2 | 53.0894 | ..... | ..... | ..... |
| 2 | 53.9659 | ..... | ..... | ..... | 2 | 45.2919 | ..... | ..... | ..... |
| 3 | 53.9814 | .9830 | .0398 | +46.03 | 2 | 45.2979 | .2996 | .0407 | +42.74 |
| 2 | 53.4142 | .4145 | .0363 | 41.71 | | | | | |

Weighted mean +44.00
 V_a -23.48
 V_d +.05
 Curvature..... - .28

Radial velocity..... +20.3

 β ORIONIS 2270.1909. Feb. 10.
G. M. T. 12^h 37^mObserved by W. E. HARPER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54.7124 | ..... | ..... | ..... | 2 | 53.0940 | ..... | ..... | ..... |
| 2 | 54.0066 | ..... | ..... | ..... | 2 | 45.2905 | ..... | ..... | ..... |
| 2 | 53.9901 | .9870 | .0438 | +49.50 | 2 | 45.3078 | .3019 | .0430 | +45.15 |
| 1 | 53.4211 | .4167 | .0385 | 44.24 | | | | | |

Weighted mean +46.71
 V_a -23.48
 V_d +.05
 Curvature..... - .28

Radial velocity..... +23.0

9-10 EDWARD VII., A. 1910

 β ORIONIS 2272.Observed by } J. S. PLASKETT.
Measured by }1909. Feb. 11.
G. M. T. 11^h 26^m

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----------------|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54° 7167 | | | | 2 | 53° 0917 | | | |
| 2 | 54° 0032 | | | | 2 | 45° 2881 | | | |
| 2 | 53° 9806 | 9785 | 0353 | +40° 82 | 2 | 45° 2997 | 3052 | 0463 | +48° 62 |
| 1 $\frac{1}{2}$ | 53° 4114 | 4092 | 0310 | 35° 62 | | | | | |

Weighted mean..... + 42° 78

 V_a 23° 65 V_d 10

Curvature..... 28

Radial velocity..... 18° 9

 β ORIONIS 2273.Observed by } J. S. PLASKETT.
Measured by }1909. Feb. 11.
G. M. T. 11^h 32^m

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54° 7138 | | | | 2 | 53° 0875 | | | |
| 2 | 54° 0025 | | | | 2 | 45° 2844 | | | |
| 2 | 53° 9970 | 9960 | 0528 | +61° 06 | 2 | 45° 3006 | 3098 | 0509 | +53° 45 |
| 1 | 53° 4268 | 4280 | 0498 | 57° 23 | | | | | |

Weighted mean..... 57° 25

 V_a 23° 65 V_d 10

Curvature..... 28

Radial velocity..... 33° 4

 β ORIONIS 2274.Observed by } J. S. PLASKETT.
Measured by }1909. Feb. 11.
G. M. T. 11^h 35^m

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----------------|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 54° 7114 | | | | 2 | 53° 0881 | | | |
| 2 | 54° 0044 | | | | 2 | 45° 2877 | | | |
| 2 | 53° 9812 | 9810 | 0378 | +43° 72 | 2 | 45° 3071 | 3130 | 0340 | +56° 81 |
| 1 $\frac{1}{2}$ | 53° 4353 | 4360 | 0378 | 66° 42 | | | | | |

Weighted mean..... + 43° 72

 V_a 23° 65 V_d 10

Curvature..... 28

Radial velocity..... +30° 8

SESSIONAL PAPER No. 25a

 β ORIONIS 2275.1909. Feb. 11.
G. M. T. 11^h 38^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54° 7133 | | | | 2 | 53° 0921 | | | |
| 2 | 54° 0063 | | | | 2 | 45° 2911 | | | |
| 3 | 53° 9782 | 9760 | 0328 | -36.78 | 2 | 45° 2979 | 3024 | 0435 | -45.68 |
| 2 | 53° 4256 | 4230 | 0448 | 51.48 | | | | | |

Weighted mean..... -43.52

 V_a -23.65 V_d -10

Curvature..... -28

Radial velocity..... -19.7

 β ORIONIS 2276.1909. Feb. 11.
G. M. T. 11^h 46^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54° 7082 | | | | 2 | 53° 0893 | | | |
| 2 | 53° 9963 | | | | 2 | 45° 2824 | | | |
| 2 | 53° 9792 | 9840 | 0408 | -47.19 | 2 | 45° 2835 | 2947 | 0338 | -37.59 |
| 1 | 53° 4083 | 4095 | 0313 | 35.97 | | | | | |

Weighted mean..... -41.11

 V_a -23.65 V_d -10

Curvature..... -28

Radial velocity..... +17.3

 β ORIONIS 2277.1909. Feb. 11.
G. M. T. 11^h 49^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 54° 7099 | | | | 2 | 53° 0878 | | | |
| 2 | 54° 0019 | | | | 2 | 45° 2944 | | | |
| 2 | 53° 9798 | 9810 | 0378 | -43.72 | 1½ | 45° 3021 | 3013 | 0424 | -44.52 |
| 1 | 53° 4279 | 4294 | 0312 | 58.83 | | | | | |

Weighted mean..... -47.34

 V_a -23.65 V_d -10

Curvature..... -28

Radial velocity..... -23.5

9-10 EDWARD VII., A. 1910

 β ORIONIS 2278.1909. Feb. 13.
G. M. T. 12^h 27^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3466 | | | | 2 | 58.8021 | | | |
| 2 | 61.3632 | | | | 2 | 36.1817 | | | |
| 3 | 61.3156 | 2975 | 1175 | +48.37 | 1 | 36.1930 | 2055 | 1150 | +40.31 |
| 2 | 59.7290 | 7110 | 1145 | 46.84 | | | | | |

Weighted mean..... +46.52

 V_a -24.00 V_d00

Curvature..... - .28

Radial velocity..... +22.2

 β ORIONIS 2279.1909. Feb. 13.
G. M. T. 12^h 40^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3312 | | | | 2 | 58.7858 | | | |
| 2 | 61.3531 | | | | 2 | 36.1657 | | | |
| 3 | 61.3032 | 2970 | 1165 | +48.16 | 1 | 36.1698 | 1983 | 1078 | +37.78 |
| 2 | 59.7212 | 7180 | 1215 | 49.71 | | | | | |

Weighted mean..... +46.24

 V_a -24.00 V_d00

Curvature..... - .28

Radial velocity..... +22.0

 β ORIONIS 2280.1909. Feb. 13.
G. M. T. 12^h 53^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3520 | | | | 2 | 58.8035 | | | |
| 2 | 61.3710 | | | | 2 | 36.1748 | | | |
| 3 | 61.3192 | 2940 | 1135 | +46.92 | 1 | 36.1848 | 2642 | 1137 | +39.85 |
| 2 | 59.7314 | 7105 | 1140 | 46.64 | | | | | |

Weighted mean..... +45.65

 V_a -24.00 V_d00

Curvature..... - .28

Radial velocity..... +21.4

SESSIONAL PAPER No. 25a

 β ORIONIS 2284.1909. Feb. 20.
G. M. T. 12^h 29^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3507 | ..... | ..... | ..... | 2 | 58.8010 | ..... | ..... | ..... |
| 2 | 61.3686 | ..... | ..... | ..... | 2 | 36.1520 | ..... | ..... | ..... |
| 3 | 61.2988 | .3100 | .0977 | + 40.27 | 2 | 36.1728 | .1730 | .1249 | + 43.78 |
| 1 | 59.7346 | .7440 | .1202 | 49.33 | | | | | |

Weighted mean..... + 42.95
 V_a - 24.82
 V_d - .08
 Curvature..... - .28

Radial velocity..... + 17.7

 β ORIONIS 2285.1909. Feb. 20.
G. M. T. 13^h 05^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3177 | ..... | ..... | ..... | 2 | 58.7696 | ..... | ..... | ..... |
| 2 | 61.3352 | ..... | ..... | ..... | 2 | 36.1246 | ..... | ..... | ..... |
| 2 | 61.2860 | .3278 | .1155 | + 47.61 | 1½ | 36.1377 | .1653 | .1172 | + 41.08 |
| 1 | 59.7262 | .7665 | .1427 | 58.21 | | | | | |

Weighted mean..... + 47.79
 V_a - 24.82
 V_d - .08
 Curvature..... - .28

Radial velocity..... + 22.6

 β ORIONIS 2286.1909. Feb. 20.
G. M. T. 15^h 12^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ms} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3440 | ..... | ..... | ..... | 2 | 58.7989 | ..... | ..... | ..... |
| 2 | 61.3648 | ..... | ..... | ..... | 2 | 36.1571 | ..... | ..... | ..... |
| 2 | 61.3160 | .3320 | .1197 | + 49.34 | 1½ | 36.1733 | .1684 | .1203 | + 42.16 |
| 1 | 59.7233 | .7245 | .1007 | 41.08 | | | | | |

Weighted mean..... + 45.14
 V_a - 24.82
 V_d - .08
 Curvature..... - .28

Radial velocity..... + 19.8

9-10 EDWARD VII., A. 1910

 β ORIONIS 2288.1909. Feb. 21.
G. M. T. 12^h 57^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3644 | ..... | ..... | ..... | 2 | 58.8118 | ..... | ..... | ..... |
| 2 | 61.3779 | ..... | ..... | ..... | 2 | 36.1520 | ..... | ..... | ..... |
| 2 | 61.3268 | 3250 | 1127 | +46.45 | 1 | 36.1798 | 1770 | 1770 | +45.18 |
| 1 | 59.7422 | 7400 | 1162 | 47.40 | | | | | |

Weighted mean - 46.45
 V_a 25.04
 V_d 09
 Curvature28

Radial velocity..... + 21.0

 β ORIONIS 2289.1909. Feb. 21.
G. M. T. 13^h 07^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3543 | ..... | ..... | ..... | 2 | 58.8071 | ..... | ..... | ..... |
| 2 | 61.3695 | ..... | ..... | ..... | 2 | 36.1572 | ..... | ..... | ..... |
| 2 | 61.3040 | 3105 | 0982 | +40.48 | 2 | 36.1726 | 1676 | 1195 | +41.88 |
| 1 | 59.7518 | 7545 | 1307 | 53.39 | | | | | |

Weighted mean + 45.62
 V_a 25.04
 V_d 00
 Curvature28

Radial velocity..... + 18.2

 β ORIONIS 2290.1909. Feb. 21.
G. M. T. 13^h 17^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3632 | ..... | ..... | ..... | 2 | 58.8150 | ..... | ..... | ..... |
| 2 | 61.3830 | ..... | ..... | ..... | 2 | 36.1631 | ..... | ..... | ..... |
| 2 | 61.3238 | 3200 | 1077 | +44.39 | 2 | 36.1767 | 1658 | 1177 | +41.25 |
| 1 | 59.7450 | 7415 | 1177 | 48.01 | | | | | |

Weighted mean +43.86
 V_a -25.04
 V_d 09
 Curvature28

Radial velocity..... +18.4

SESSIONAL PAPER No. 25a

 β ORIONIS 2291.1909, Feb. 21.
G. M. T. 13^h 27^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3650 | | | | 2 | 58.8109 | | | |
| 2 | 61.3777 | | | | 2 | 36.1475 | | | |
| 3 | 61.3190 | -3170 | 1047 | -43.16 | 2 | 36.1659 | -1706 | 1225 | -42.94 |
| 1½ | 59.7433 | -7416 | -1168 | 47.64 | | | | | |

Weighted mean -44.13

 V_a -25.04 V_d 09

Curvature, ... - .28

Radial velocity, -18.7

 β ORIONIS 2292.1909, Feb. 22.
G. M. T. 12^h 02^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3642 | | | | 2 | 58.8102 | | | |
| 2 | 61.3755 | | | | 2 | 36.1595 | | | |
| 2 | 61.3167 | -3157 | 1034 | -42.62 | 1 | 36.1831 | -1758 | 1277 | -44.76 |
| 1 | 59.7493 | -7483 | -1245 | 50.78 | | | | | |

Weighted mean -45.19

 V_a -25.14 V_d 02

Curvature, ... - .28

Radial velocity, +19.7

 β ORIONIS 2293.1909, Feb. 22.
G. M. T. 12^h 15^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^m | Velocity. |
|-----|-------------------|--------------------------|--|-----------|-----|-------------------|--------------------------|--|-----------|
| 2 | 63.3503 | | | | 2 | 58.8000 | | | |
| 2 | 61.3637 | | | | 2 | 36.1558 | | | |
| 2 | 61.3018 | -3125 | 1002 | -41.30 | ½ | 36.1807 | -1771 | 1290 | -45.21 |
| 1 | 59.7474 | -7570 | -1332 | 54.33 | | | | | |

Weighted mean +45.58

 V_a -25.14 V_d 02

Curvature, ... - .28

Radial velocity, +25.1

9-10 EDWARD VII., A. 1910

 β ORIONIS 2294.1909. Feb. 29.
G. M. T. 12^h 30^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3495 | ..... | ..... | ..... | 2 | 58.8022 | ..... | ..... | ..... |
| 2 | 63.3678 | ..... | ..... | ..... | 2 | 36.1610 | ..... | ..... | ..... |
| 2 | 61.3121 | .3210 | .1087 | -44.81 | 2 | 36.1809 | .1720 | .1239 | -43.43 |
| 1½ | 59.7381 | .7458 | .1220 | 49.76 | | | | | |

Weighted mean..... +45.66

 V_a -25.14 V_d02

Curvature..... .28

Radial velocity..... +20.2

 β ORIONIS 2295.1909. Feb. 22.
G. M. T. 12^h 42^mObserved by T. H. PARKER.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3622 | ..... | ..... | ..... | 2 | 58.8005 | ..... | ..... | ..... |
| 2 | 61.3780 | ..... | ..... | ..... | 2 | 36.1677 | ..... | ..... | ..... |
| 2 | 61.3248 | .3280 | .1157 | -47.69 | 1½ | 36.1881 | .1726 | .1245 | +43.64 |
| 2 | 59.7345 | .7344 | .1106 | 45.11 | | | | | |

Weighted mean..... +45.65

 V_a -25.14 V_d02

Curvature..... .28

Radial velocity..... +20.2

 β ORIONIS 2309.1909. Feb. 27.
G. M. T. 11^h 35^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3682 | ..... | ..... | ..... | 2 | 58.8129 | ..... | ..... | ..... |
| 2 | 61.3790 | ..... | ..... | ..... | 2 | 36.1491 | ..... | ..... | ..... |
| 2 | 61.3288 | .3240 | .1117 | -46.04 | 2 | 36.1814 | .1845 | .1364 | +47.81 |
| 1½ | 59.7498 | .7460 | .1222 | 49.85 | | | | | |

Weighted mean..... +47.71

 V_a -25.48 V_d00

Curvature..... .28

Radial velocity..... +22.0

SESSIONAL PAPER No. 25a

 β ORIONIS 2311.1900. Feb. 28.
G. M. T. 11^h 56^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3272 | | | | 2 | 58.7792 | | | |
| 2 | 63.3402 | | | | 2 | 36.1567 | | | |
| 2 | 61.2889 | 2940 | 1135 | +46.92 | 14 | 36.1805 | 2180 | 1275 | +44.83 |
| 1½ | 59.7215 | 7250 | 1285 | 52.63 | | | | | |

Weighted mean. +48.01

 V_a 25.53 V_d 02

Curvature28

Radial velocity. +22.2

 β ORIONIS 2312.1900. Feb. 28.
G. M. T. 12^h 07^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.2345 | | | | 2 | 58.7913 | | | |
| 2 | 61.3567 | | | | 2 | 36.1739 | | | |
| 3 | 61.2980 | 2890 | 1085 | +44.85 | 2 | 36.2048 | 2251 | 1346 | +47.33 |
| 2 | 59.7342 | 7260 | 1295 | 53.04 | | | | | |

Weighted mean. +47.90

 V_a 25.53 V_d 02

Curvature28

Radial velocity. +22.0

 β ORIONIS 2313.1900. Feb. 28.
G. M. T. 12^h 18^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displ ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63.3394 | | | | 2 | 58.7911 | | | |
| 2 | 61.3602 | | | | 2 | 36.1740 | | | |
| 2 | 61.3112 | 3000 | 1195 | +49.40 | 1 | 36.1806 | 2026 | 1121 | +39.41 |
| 1 | 59.7515 | 7435 | 1470 | 60.21 | | | | | |

Weighted mean. +49.61

 V_a 25.53 V_d 02

Curvature28

Radial velocity. +23.7

9-10 EDWARD VII., A. 1910

 β ORIONIS 2314.1909. Feb. 28.
G. M. T. 12^h 27^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63°32'28 | | | | 2 | 58°7'56 | | | |
| 2 | 61°3'467 | | | | 2 | 36°17'42 | | | |
| 2 | 61°30'37 | 3005 | 1200 | -49°61 | 1½ | 36°19'98 | 2198 | 1293 | -45°46 |
| 1½ | 59°7'434 | 7408 | 1443 | 59°11 | | | | | |

Weighted mean..... +51°22

 V_a -25°53 V_d -°02

Curvature..... -°28

Radial velocity..... +25°3

 β ORIONIS 2315.1909. Feb. 28.
G. M. T. 12^h 39^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63°32'47 | | | | 2 | 58°7'59 | | | |
| 2 | 61°3'422 | | | | 2 | 36°15'41 | | | |
| 3 | 61°29'79 | 3005 | 1200 | +49°61 | 2 | 36°17'57 | 2158 | 1253 | +44°06 |
| 1½ | 59°7'148 | 7215 | 1250 | 51°14 | | | | | |

Weighted mean..... +48°26

 V_a -25°53 V_d -°02

Curvature..... -°28

Radial velocity..... -22°4

 β ORIONIS 2316.1909. Feb. 28.
G. M. T. 12^h 50^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|--|-----------|-----|-------------------------|--------------------------------|--|-----------|
| 2 | 63°33'55 | | | | 2 | 58°7'887 | | | |
| 2 | 61°35'28 | | | | 2 | 36°17'82 | | | |
| 2 | 61°29'98 | 2920 | 1115 | -46°09 | 1½ | 36°19'44 | 2105 | 1200 | +42°19 |
| 1½ | 59°7'455 | 7400 | 1435 | 58°71 | | | | | |

Weighted mean..... +48°71

 V_a -25°53 V_d -°02

Curvature..... -°28

Radial velocity..... -22°8

SESSIONAL PAPER No. 25a

 β ORIONIS 2317.1909, Mar. 2.
G. M. T. 11^h 20^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 63.3647 | ..... | ..... | ..... | 2 | 58.8147 | ..... | ..... | ..... |
| 2 | 61.3807 | ..... | ..... | ..... | 2 | 36.1744 | ..... | ..... | ..... |
| 2 | 61.3360 | .3320 | .1197 | +49.34 | 1½ | 36.1960 | .1738 | .1257 | +44.06 |
| 2 | 59.7707 | .7655 | .1417 | 57.80 | | | | | |

Weighted mean..... +50.97
 V_d -25.61
 V_d - .02
 Curvature..... - .28

Radial velocity..... +25.9

 γ ORIONIS 2318.1909, Mar. 2.
G. M. T. 11^h 19^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 63.3626 | ..... | ..... | ..... | 2 | 59.8975 | ..... | ..... | ..... |
| 2 | 61.3804 | ..... | ..... | ..... | 2 | 36.1516 | ..... | ..... | ..... |
| 2 | 61.3217 | .3210 | .1087 | -44.81 | 1½ | 36.1860 | .1866 | .1385 | +48.54 |
| 2 | 59.7622 | .7640 | .1402 | 57.19 | | | | | |

Weighted mean..... +50.33
 V_d -25.61
 V_d - .02
 Curvature..... - .28

Radial velocity..... +24.4

 β ORIONIS 2319.1909, Mar. 2.
G. M. T. 11^h 29^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt ^t in rev ^{ns} | Velocity. |
|-----|-------------------|--------------------------|---|-----------|-----|-------------------|--------------------------|---|-----------|
| 2 | 63.3438 | ..... | ..... | ..... | 2 | 58.7920 | ..... | ..... | ..... |
| 2 | 61.3600 | ..... | ..... | ..... | 2 | 36.1442 | ..... | ..... | ..... |
| 2 | 61.3690 | .3230 | .1137 | +46.87 | 2 | 36.1763 | .1843 | .1363 | +47.77 |
| 1½ | 59.7476 | .7650 | .1412 | 57.59 | | | | | |

Weighted mean..... +50.12
 V_d -25.61
 V_d - .02
 Curvature..... - .28

Radial velocity..... +24.2

9-10 EDWARD VII., A. 1913

 β ORIONIS 2320.1909. Mar. 2.
G. M. T. 11^h 36^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3522 | ..... | ..... | ..... | 2 | 58.7996 | ..... | ..... | ..... |
| 2 | 61.3707 | ..... | ..... | ..... | 2 | 36.1541 | ..... | ..... | ..... |
| 2 | 61.3197 | .3290 | .1167 | +48.10 | 2 | 36.1921 | .1902 | .1421 | +49.81 |
| 1½ | 59.7315 | .7312 | .1074 | 43.81 | | | | | |

Weighted mean..... +47.55

 V_s -25.61 V_d - .02

Curvature.... - .28

Radial velocity +21.6

 β ORIONIS 2364.1909. Mar. 13
G. M. T. 12^h 12^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3696 | ..... | ..... | ..... | 2 | 58.8145 | ..... | ..... | ..... |
| 2 | 61.3879 | ..... | ..... | ..... | 2 | 36.1448 | ..... | ..... | ..... |
| 2 | 61.3327 | .3250 | .1127 | +46.5 | 1½ | 36.1611 | .1685 | .1204 | -42.2 |
| 1½ | 59.7380 | .7320 | .1082 | 44.1 | | | | | |

Weighted mean..... +44.50

 V_s -25.45 V_d - .16

Curvature.... - .28

Radial velocity +18.6

 β ORIONIS 2365.1909. Mar. 13
G. M. T. 12^h 24^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3760 | ..... | ..... | ..... | 2 | 58.8161 | ..... | ..... | ..... |
| 2 | 61.3876 | ..... | ..... | ..... | 2 | 36.1348 | ..... | ..... | ..... |
| 3 | 61.3228 | .3120 | .0997 | +41.1 | 1½ | 36.1591 | .1765 | .1284 | +45.0 |
| 2 | 59.7507 | .7425 | .1187 | 48.4 | | | | | |

Weighted mean..... +44.25

 V_s -25.45 V_d - .16

Curvature.... - .28

Radial velocity..... +18.4

SESSIONAL PAPER No. 25a

 β ORIONIS 2365.1909. Mar. 13.
G. M. T. 12^h 36^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3662 | ..... | ..... | ..... | 2 | 58.8112 | ..... | ..... | ..... |
| 2 | 61.3821 | ..... | ..... | ..... | 2 | 36.1400 | ..... | ..... | ..... |
| 2 | 61.3198 | 3160 | 1037 | +42.7 | 1½ | 36.1692 | 1814 | 1333 | +46.7 |
| 1½ | 59.7506 | 7475 | 1237 | 50.4 | | | | | |

Weighted mean..... +46.21

 V_a -25.45 V_d -16

Curvature..... -28

Radial velocity..... +20.3

 β ORIONIS 2367.1909. Mar. 13.
G. M. T. 12^h 46^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3600 | ..... | ..... | ..... | 2 | 58.7981 | ..... | ..... | ..... |
| 2 | 61.3738 | ..... | ..... | ..... | 2 | 36.1272 | ..... | ..... | ..... |
| 2½ | 61.3086 | 3125 | 1002 | +41.30 | 1½ | 36.1460 | 1710 | 1229 | +43.10 |
| 1½ | 59.7297 | 7400 | 1162 | 47.40 | | | | | |

Weighted mean..... +43.45

 V_a -25.45 V_d -16

Curvature..... -28

Radial velocity..... +17.6

 β ORIONIS 2368.1909. Mar. 13.
G. M. T. 12^h 57^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63.3640 | ..... | ..... | ..... | 2 | 58.8093 | ..... | ..... | ..... |
| 2 | 61.3800 | ..... | ..... | ..... | 2 | 36.1354 | ..... | ..... | ..... |
| 2 | 61.3300 | 3280 | 1157 | +47.7 | 1½ | 36.1578 | 1746 | 1265 | +44.3 |
| 2 | 59.7306 | 7300 | 1062 | 43.3 | | | | | |

Weighted mean..... +45.17

 V_a -25.45 V_d -16

Curvature..... -28

Radial velocity..... +19.3

9-10 EDWARD VII., A. 1910

 β ORIONIS 2372.1909. Mar. 15.
G. M. T. 11^h 45^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 63.3472 | | | | 2 | 58.8015 | | | |
| 2 | 61.3664 | | | | 2 | 36.1624 | | | |
| 2 | 61.3098 | 2890 | 1085 | -44.85 | 1½ | 36.1712 | 2630 | 1125 | +39.55 |
| 1 | 59.7205 | 7015 | 1050 | 42.96 | | | | | |

Weighted mean +42.66
 V_d -25.34
 V_d -14
Curvature -28

Radial velocity +16.9

 β ORIONIS 2373.1909. Mar. 15.
G. M. T. 11^h 50^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 63.3475 | | | | 2 | 58.7985 | | | |
| 2 | 61.3660 | | | | 2 | 36.1478 | | | |
| 2½ | 61.3094 | 2890 | 1085 | -44.85 | 1½ | 36.1697 | 2161 | 1256 | +44.16 |
| 1 | 59.7421 | 7260 | 1255 | 52.98 | | | | | |

Weighted mean +46.27
 V_d -25.34
 V_d -14
Curvature -28

Radial velocity +20.5

 β ORIONIS 2374.1909. Mar. 15.
G. M. T. 12^h 05^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 63.3415 | | | | 2 | 58.7942 | | | |
| 2 | 61.3612 | | | | 2 | 36.1568 | | | |
| 2 | 61.2924 | 2764 | 0959 | -39.65 | 1½ | 36.1784 | 2128 | 1223 | -43.00 |
| 1 | 59.7336 | 7220 | 1255 | 51.34 | | | | | |

Weighted mean +43.36
 V_d -25.34
 V_d -14
Curvature -28

Radial velocity +17.6

SESSIONAL PAPER No. 25a

 β ORIONIS 2375.1909, Mar. 15.
G. M. T. 12^h 13^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 63.3439 | ..... | ..... | ..... | 2 | 58.7960 | ..... | ..... | ..... |
| 2 | 61.3618 | ..... | ..... | ..... | 2 | 36.1654 | ..... | ..... | ..... |
| 2 | 61.3146 | 2976 | 1171 | +48.41 | 1½ | 36.1837 | 2125 | 1223 | +43.00 |
| 1½ | 59.7102 | 6972 | 1007 | 41.20 | | | | | |

Weighted mean..... +44.62

 V_{α} -25.34 V_{β} -14

Curvature..... -28

Radial velocity..... +18.9

 β ORIONIS 2376.1909, Mar. 15.
G. M. T. 12^h 21^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 63.3492 | ..... | ..... | ..... | 2 | 58.8022 | ..... | ..... | ..... |
| 2 | 61.3678 | ..... | ..... | ..... | 2 | 36.1743 | ..... | ..... | ..... |
| 2 | 61.3082 | 2809 | 0995 | +41.13 | 1 | 36.1771 | 1970 | 1065 | +37.45 |
| 1½ | 59.7281 | 7088 | 1123 | 45.94 | | | | | |

Weighted mean..... +41.92

 V_{α} -25.34 V_{β} -14

Curvature..... -28

Radial velocity..... +16.2

 β ORIONIS 2386.1909, Mar. 18.
G. M. T. 11^h 42^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^m | Velocity. |
|-----|-------------------------|--------------------------------|------------------------------|-----------|-----|-------------------------|--------------------------------|------------------------------|-----------|
| 2 | 63.3427 | ..... | ..... | ..... | 2 | 58.7936 | ..... | ..... | ..... |
| 2 | 61.3610 | ..... | ..... | ..... | 2 | 36.1518 | ..... | ..... | ..... |
| 3 | 61.3920 | 3185 | 1062 | -43.78 | 1 | 36.1820 | 1824 | 1343 | +47.07 |
| 2 | 59.7188 | 7346 | 1108 | 45.20 | | | | | |

Weighted mean..... +44.98

 V_{α} -25.00 V_{β} -15

Curvature..... -28

Radial velocity..... +19.5

9-10 EDWARD VII., A. 1910

 β ORIONIS 2387.1909, Mar. 18,
G. M. T. 11^h 52^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3645 | ..... | ..... | ..... | 2 | 58.8071 | ..... | ..... | ..... |
| 2 | 61.3782 | ..... | ..... | ..... | 2 | 36.1581 | ..... | ..... | ..... |
| 2 | 61.3205 | .3200 | .1077 | +44.39 | 1 | 36.1684 | .1625 | .1144 | +40.10 |
| 1½ | 59.7405 | .7480 | .1242 | 50.66 | | | | | |

Weighted mean..... -45.53

V_a..... -25.09V_d..... -15

Curvature..... -28

Radial velocity..... +20.0

 β ORIONIS 2388.1909, Mar. 18,
G. M. T. 12^h 02^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3541 | ..... | ..... | ..... | 2 | 58.8001 | ..... | ..... | ..... |
| 2 | 61.3718 | ..... | ..... | ..... | 2 | 36.1635 | ..... | ..... | ..... |
| 2 | 61.3210 | .3280 | .1157 | +47.09 | 1½ | 36.1828 | .1715 | .1235 | +43.29 |
| 1½ | 59.7396 | .7480 | .1242 | 50.66 | | | | | |

Weighted mean..... -47.26

V_a..... -25.09V_d..... -15

Curvature..... -28

Radial velocity..... -21.7

 β ORIONIS 2389.1909, Mar. 18,
G. M. T. 12^h 12^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3492 | ..... | ..... | ..... | 2 | 58.7998 | ..... | ..... | ..... |
| 2 | 61.3646 | ..... | ..... | ..... | 2 | 36.1597 | ..... | ..... | ..... |
| 1½ | 61.2927 | .3050 | .0927 | +38.21 | 1½ | 36.1954 | .1879 | .1398 | +49.00 |
| 2 | 59.7380 | .7485 | .1247 | 50.86 | | | | | |

Weighted mean..... -46.51

V_a..... -25.09V_d..... -15

Curvature..... -28

Radial velocity..... -21.0

SESSIONAL PAPER No. 25a

 β ORIONIS 2390.1909, Mar. 20.
G. M. T. 12^h 16^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63 3657 | | | | 2 | 58 8128 | | | |
| 2 | 61 3836 | | | | 2 | 36 1496 | | | |
| 2½ | 61 3307 | 3260 | 1137 | +46 86 | 1½ | 36 1655 | 1681 | 1290 | +42 06 |
| 1½ | 59 7601 | 7561 | 1323 | 53 96 | | | | | |

Weighted mean +47 49
 V_a -24 88
 V_d -12
Curvature..... -28

Radial velocity..... +22 2

 β ORIONIS 2391.1909, Mar. 20.
G. M. T. 12^h 26^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63 3724 | | | | 2 | 58 8192 | | | |
| 2 | 61 3859 | | | | 2 | 36 1414 | | | |
| 2 | 61 3292 | 3192 | 1069 | +44 06 | 1½ | 36 1637 | 1745 | 1264 | +44 30 |
| 1½ | 59 7392 | 7292 | 1054 | 42 99 | | | | | |

Weighted mean..... +43 81
 V_a -24 88
 V_d -12
Curvature..... -28

Radial velocity..... +18 3

 β ORIONIS 2392.1909, Mar. 20.
G. M. T. 12^h 38^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63 3775 | | | | 2 | 58 8197 | | | |
| 2 | 61 3892 | | | | 2 | 36 1569 | | | |
| 3 | 61 3352 | 3320 | 1197 | +49 34 | 2 | 36 1862 | 1815 | 1334 | +46 76 |
| 1½ | 59 7575 | 7460 | 1222 | 49 85 | | | | | |

Weighted mean..... +48 66
 V_a -24 88
 V_d -12
Curvature..... -28

Radial velocity ... +25 4

9-10 EDWARD VII., A. 1910

 β ORIONIS 2393.1909. Mar. 20.
G. M. T. 12^h 48^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63° 3659 | ..... | ..... | ..... | 2 | 58° 8108 | ..... | ..... | ..... |
| 2 | 61° 3800 | ..... | ..... | ..... | 2 | 36° 1480 | ..... | ..... | ..... |
| 2 | 61° 3215 | 3184 | 1061 | +43° 75 | 1½ | 36° 1857 | 1900 | 1419 | +49° 74 |
| 1½ | 59° 7468 | 7448 | 1210 | 49° 36 | | | | | |

Weighted mean..... +47° 22

 V_a -24° 88 V_d 12

Curvature..... -28

Radial velocity..... +21° 9

 β ORIONIS 2394.1909. Mar. 20.
G. M. T. 12^h 58^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63° 3661 | ..... | ..... | ..... | 2 | 58° 8130 | ..... | ..... | ..... |
| 2 | 61° 3815 | ..... | ..... | ..... | 2 | 36° 1565 | ..... | ..... | ..... |
| 2½ | 61° 3319 | 3275 | 1152 | +47° 49 | 1½ | 36° 1806 | 1763 | 1282 | +44° 93 |
| 1½ | 59° 7587 | 7547 | 1300 | 53° 30 | | | | | |

Weighted mean..... +48° 40

 V_a -24° 88 V_d 12

Curvature..... -28

Radial velocity..... +23° 1

 β ORIONIS 2397.1909. Mar. 21.
G. M. T. 13^h 38^mObserved by J. S. PLASKETT.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Dispt in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 63° 3695 | ..... | ..... | ..... | 2 | 58° 8189 | ..... | ..... | ..... |
| 2 | 61° 3856 | ..... | ..... | ..... | 2 | 36° 1752 | ..... | ..... | ..... |
| 2 | 61° 3328 | 3240 | 1117 | +46° 07 | 1½ | 36° 2220 | 1999 | 1509 | +52° 80 |
| 2 | 59° 7550 | 7460 | 1222 | 49° 85 | | | | | |

Weighted mean..... +49° 30

 V_a -24° 76 V_d 32

Curvature..... -28

Radial velocity..... +23° 9

SESSIONAL PAPER No. 25a

 β ORIONIS 2388.1909, Mar. 21.
G. M. T. 13^h 48^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------------------|-----------|-----|-------------------|--------------------------|---------------------------------------|-----------|
| 2 | 63.3667 | | | | 2 | 58.8120 | | | |
| 2 | 61.3818 | | | | 2 | 36.1571 | | | |
| 2 | 61.3396 | 3350 | 1227 | +50.60 | 2 | 36.2053 | 2004 | 1523 | +53.38 |
| 2 | 59.7441 | 7410 | 1172 | 47.81 | | | | | |

Weighted mean..... +50.60

 V_a -24.76 V_d -32

Curvature..... -28

Radial velocity..... +25.2

 β ORIONIS 2390.1909, Mar. 21.
G. M. T. 14^hObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------------------|-----------|-----|-------------------|--------------------------|---------------------------------------|-----------|
| 2 | 63.3483 | | | | 2 | 58.7972 | | | |
| 2 | 61.3664 | | | | 2 | 36.1511 | | | |
| 2 | 61.3124 | 3245 | 1122 | +46.27 | 1 | 36.1884 | 1894 | 1414 | +49.56 |
| 2 | 59.7452 | 7572 | 1334 | 54.41 | | | | | |

Weighted mean..... +50.18

 V_a -24.76 V_d -32

Curvature..... -28

Radial velocity..... +24.8

 β ORIONIS 2400.1909, Mar. 21.
G. M. T. 14^h 14^mObserved by J. S. PLASKETT.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------------------|-----------|-----|-------------------|--------------------------|---------------------------------------|-----------|
| 2 | 63.3505 | | | | 2 | 58.8071 | | | |
| 2 | 61.3712 | | | | 2 | 36.1516 | | | |
| 2 | 61.3198 | 3300 | 1177 | +48.54 | 2 | 36.1855 | 1861 | 1380 | +48.57 |
| 1½ | 59.7490 | 7580 | 1342 | 54.74 | | | | | |

Weighted mean..... +50.84

 V_a -24.76 V_d -32

Curvature..... -28

Radial velocity..... +25.5

9-10 EDWARD VII., A. 1910

 β ORIONIS 2402.1909, Mar. 22.
G. M. T. 11^h 51^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3584 | ..... | ..... | ..... | 2 | 58.8043 | ..... | ..... | ..... |
| 2 | 61.3737 | ..... | ..... | ..... | 2 | 36.1447 | ..... | ..... | ..... |
| 2 | 61.3370 | .3410 | .1287 | +53.05 | 1½ | 36.1712 | .1787 | .1307 | +45.81 |
| 1½ | 59.7510 | .7560 | .1322 | 53.92 | | | | | |

Weighted mean..... 51.14

V_a..... -24.66V_d..... -16

Curvature..... -28

Radial velocity..... -26.0

 β ORIONIS 2403.1909, Mar. 22.
G. M. T. 12^h 02^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3517 | ..... | ..... | ..... | 2 | 58.8000 | ..... | ..... | ..... |
| 2 | 61.3688 | ..... | ..... | ..... | 2 | 36.1536 | ..... | ..... | ..... |
| 2 | 61.3260 | .3355 | .1232 | +50.78 | 1½ | 36.1846 | .1832 | .1832 | +47.35 |
| 1½ | 59.7423 | .7573 | .1275 | 52.01 | | | | | |

Weighted mean..... +50.12

V_a..... -24.66V_d..... -16

Curvature..... -28

Radial velocity..... +25.0

 β ORIONIS 2404.1909, Mar. 22.
G. M. T. 12^h 13^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3608 | ..... | ..... | ..... | 2 | 58.8094 | ..... | ..... | ..... |
| 2 | 61.3126 | ..... | ..... | ..... | 2 | 36.1640 | ..... | ..... | ..... |
| 2 | 61.3242 | .3260 | .1137 | +46.87 | 1½ | 36.1917 | .1800 | .1319 | +46.23 |
| 1½ | 59.7329 | .7335 | .1107 | 45.15 | | | | | |

Weighted mean..... +46.16

V_a..... -24.66V_d..... -16

Curvature..... -28

Radial velocity..... +21.1

SESSIONAL PAPER No. 25a

 β ORIONIS 2405.1909. Mar. 22.
G. M. T. 12^h 35^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63 3570 | ..... | ..... | ..... | 2 | 58 8019 | ..... | ..... | ..... |
| 2 | 61 3713 | ..... | ..... | ..... | 2 | 36 1480 | ..... | ..... | ..... |
| 2 | 61 3438 | 3228 | 1105 | +45 55 | 1½ | 36 1698 | 1740 | 1259 | +44 13 |
| 1½ | 59 7373 | 7450 | 1212 | 49 44 | | | | | |

Weighted mean +46 29

 V_a -24 66 V_d -16

Curvature -28

Radial velocity +21 2

 β ORIONIS 2420.1909. Mar. 23.
G. M. T. 11^h 46^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63 3586 | ..... | ..... | ..... | 2 | 58 8059 | ..... | ..... | ..... |
| 2 | 61 3757 | ..... | ..... | ..... | 2 | 36 1332 | ..... | ..... | ..... |
| 1½ | 61 3160 | 3190 | 1067 | +43 99 | 2 | 36 1699 | 1889 | 1408 | +49 35 |
| 1½ | 59 7445 | 7480 | 1242 | 50 66 | | | | | |

Weighted mean +48 14

 V_a -24 54 V_d -19

Curvature -28

Radial velocity +23 1

 β ORIONIS 2421.1909. Mar. 23.
G. M. T. 11^h 57^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63 3700 | ..... | ..... | ..... | 2 | 58 8151 | ..... | ..... | ..... |
| 2 | 61 3800 | ..... | ..... | ..... | 2 | 36 1310 | ..... | ..... | ..... |
| 2½ | 61 3418 | 3358 | 1235 | +50 92 | 2 | 36 1608 | 1820 | 1339 | +46 93 |
| 1½ | 59 7447 | 7390 | 1152 | 49 99 | | | | | |

Weighted mean +49 36

 V_a -24 54 V_d -19

Curvature -23

Radial velocity +24 4

9-10 EDWARD VII., A. 1913

 β ORIONIS 2422.1909. Mar. 23.
G. M. T. 12^h 03^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------------------|-----------|-----|-------------------|--------------------------|---------------------------------------|-----------|
| 2 | 63.3572 | | | | 2 | 58.8081 | | | |
| 2 | 61.3728 | | | | 2 | 36.1372 | | | |
| 2 | 61.3253 | 3290 | 1177 | 48.53 | 2 | 36.1920 | 2070 | 1589 | +55.69 |
| 1 | 59.7348 | 7370 | 1132 | 46.17 | | | | | |

Weighted mean..... +50.92

 V_a -24.54 V_d -19

Curvature..... -28

Radial velocity..... +25.9

 β ORIONIS 2423.1909. Mar. 23.
G. M. T. 12^h 13^mObserved by } J. S. PLASKETT.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------------------|-----------|-----|-------------------|--------------------------|---------------------------------------|-----------|
| 2 | 62.3787 | | | | 2 | 58.8225 | | | |
| 2 | 61.3936 | | | | 2 | 36.1500 | | | |
| 2 | 61.3330 | 3170 | 1047 | +43.17 | 2 | 36.2082 | 2104 | 1623 | +56.89 |
| 2 | 59.7696 | 7351 | 1313 | 53.56 | | | | | |

Weighted mean..... +51.21

 V_a -24.54 V_d -19

Curvature..... -28

Radial velocity..... +26.2

 β ORIONIS 2424.1909. Mar. 23.
G. M. T. 12^h 27^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^d in rev ^m | Velocity. |
|-----|-------------------|--------------------------|---------------------------------------|-----------|-----|-------------------|--------------------------|---------------------------------------|-----------|
| 2 | 63.3774 | | | | 2 | 58.8212 | | | |
| 2 | 61.3930 | | | | 2 | 36.1341 | | | |
| 1½ | 61.3425 | 3275 | 1152 | -47.51 | 2 | 36.1822 | 1997 | 1516 | +53.14 |
| 1½ | 59.7590 | 7465 | 1227 | 50.35 | | | | | |

Weighted mean..... +50.32

 V_a -24.54 V_d -19

Curvature..... -28

Radial velocity..... +25.5

SESSIONAL PAPER No. 25a

 β ORIONIS 2425.1909. Mar. 23.
G. M. T. 12^h 38^mObserved by J. B. CANNON.
Measured by J. S. PLASKETT.

| Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Disp ^t in rev ^{ns} | Velocity. |
|-----|-------------------------|--------------------------------|---|-----------|-----|-------------------------|--------------------------------|---|-----------|
| 2 | 63.3650 | | | | 2 | 58.8098 | | | |
| 2 | 61.3793 | | | | 2 | 36.1269 | | | |
| 2 | 61.3350 | 3327 | 1204 | +49.65 | 1½ | 36.1707 | 1960 | 1479 | -51.84 |
| 1½ | 59.7498 | 7490 | 1252 | 51.07 | | | | | |

Weighted mean..... +50.72

V_a..... -25.54V_d..... -19

Curvature..... -28

Radial velocity..... +25.7

SESSIONAL PAPER No. 25a

| | | | | | | | | | | | | | | | | |
|------|----|------|----|----|----|----|----|----|----|----|----|----|----|---|------|------------------|
| 1755 | 31 | 17 | 52 | 25 | 1 | 36 | 19 | 18 | 7 | 25 | 5 | 25 | 6 | " | " | P ₁ H |
| 1756 | " | 31 | 18 | 19 | 21 | " | 18 | 7 | 18 | 5 | 25 | 6 | " | " | " | H |
| 1757 | " | Aug. | 14 | 43 | 50 | 1 | 22 | 6 | 22 | 6 | 27 | 0 | 27 | 0 | Fair | P |
| 1758 | " | " | 5 | 16 | 29 | 38 | 1 | 21 | 6 | 21 | 6 | 26 | 8 | " | " | P |
| 1759 | " | " | 5 | 17 | 18 | 48 | 1 | 25 | " | 21 | 3 | 26 | 8 | " | " | P |
| 1760 | " | " | 5 | 18 | 48 | 30 | 2 | 47 | " | 20 | 5 | 26 | 5 | " | " | C |
| 1761 | " | " | 7 | 17 | 00 | 40 | 1 | 15 | " | 19 | 3 | 23 | 6 | " | " | P |
| 1762 | " | " | 7 | 17 | 45 | 40 | 2 | 02 | " | 19 | 2 | 23 | 5 | " | " | P |
| 1763 | " | " | 17 | 18 | 18 | 34 | 3 | 11 | " | 18 | 8 | 23 | 4 | " | " | P |
| 1764 | " | " | 19 | 16 | 45 | 90 | 2 | 12 | " | 18 | 5 | 26 | 2 | " | " | P |
| 1765 | " | " | 20 | 15 | 15 | 39 | 2 | 20 | " | 17 | 0 | 22 | 3 | " | " | P |
| 1766 | " | " | 20 | 15 | 47 | 25 | 47 | " | " | 17 | 0 | 22 | 3 | " | " | P |
| 1767 | " | " | 20 | 16 | 42 | 29 | 1 | 43 | " | 17 | 0 | 22 | 3 | " | " | P |
| 1768 | " | " | 21 | 13 | 57 | 35 | 1 | 26 | " | 18 | 2 | 25 | 4 | " | " | P |
| 1769 | " | " | 21 | 14 | 32 | 30 | 30 | W. | " | 18 | 8 | 25 | 2 | " | " | P |
| 1770 | " | " | 21 | 15 | 28 | 30 | 30 | W. | " | 18 | 4 | 25 | 4 | " | " | P |
| 1771 | " | " | 22 | 15 | 29 | 26 | 37 | " | " | 15 | 5 | 18 | 0 | " | " | P |
| 1772 | " | " | 22 | 15 | 56 | 25 | 1 | 03 | " | 15 | 5 | 17 | 8 | " | " | P |
| 1773 | " | " | 22 | 16 | 21 | 26 | 1 | 29 | " | 16 | 0 | 17 | 8 | " | " | P |
| 1774 | " | " | 23 | 15 | 48 | 27 | 1 | 02 | " | 18 | 0 | 20 | 5 | " | " | P |
| 1775 | " | " | 23 | 16 | 18 | 30 | 2 | 30 | " | 17 | 5 | 20 | 3 | " | " | P |
| 1776 | " | " | 24 | 16 | 56 | 32 | 2 | 15 | " | 14 | 4 | 23 | 8 | " | " | P |
| 1777 | " | " | 27 | 14 | 02 | 35 | 25 | " | " | 18 | 6 | 23 | 2 | " | " | P |
| 1778 | " | " | 3 | 16 | 17 | 55 | 30 | W. | " | 14 | 8 | 20 | 5 | " | " | P |
| 1779 | " | " | 8 | 12 | 42 | 45 | 35 | E. | " | 21 | 0 | 22 | 9 | " | " | P |
| 1780 | " | " | 8 | 13 | 40 | 69 | 20 | W. | " | 20 | 4 | 22 | 7 | " | " | P |
| 1781 | " | " | 11 | 15 | 00 | 60 | 1 | 47 | " | 22 | 5 | 28 | 2 | " | " | P |
| 1782 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | " | P |
| 1783 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | " | P |
| 1784 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | " | P |
| 1785 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | " | P |
| 1786 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | " | P |
| 1787 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | " | P |
| 1788 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | " | P |

Windy.

Cloudy 29thOff 5th

Unsteady.

Good.

Fair.

Good.

Fair.

Good.

Fair.

Good.

Fair.

Good.

Fair.

Good.

Fair.

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Good.

Fair.

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Fair.

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Fair.

Good.

Fair.

Good.

Fair.

Good.

Fair.

Good.

Fair.

Good.

9-10 EDWARD VII., A. 1910

AQUILÆ 1038.

1907. Sept. 12.
G. M. T. 15^h 15^mObserved by J. N. TRIBBLE.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7334 | | | | $\frac{1}{2}$ | 27.3601 | 4161 | .0035 | 3.04 |
| 1 | 53.9733 | .9818 | .0120 | +13.81 | 2 | 27.1906 | | | |
| 2 | 53.1041 | | | | $1\frac{1}{2}$ | 11.7684 | .8670 | .0156 | +11.68 |
| 2 | 45.2469 | | | | 2 | 11.4086 | | | |
| $1\frac{1}{2}$ | 45.2273 | .2540 | .0153 | 15.97 | | | | | |

Weighted mean. +12.62
 V_a -20.23
 V_d -14
Curvature. -28
Radial velocity. -8.0

AQUILÆ 1050.

1907. Sept. 18.
G. M. T. 14^h 45^mObserved by J. N. TRIBBLE.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0318 | | | | 2 | 45.2738 | | | |
| 1 | 72.8699 | .8031 | .0156 | -22.66 | $1\frac{1}{2}$ | 45.2139 | .2237 | .0250 | 26.17 |
| 2 | 72.4635 | | | | $\frac{1}{2}$ | 27.3813 | .4591 | .0374 | -32.59 |
| 2 | 54.0294 | | | | 2 | 27.2441 | | | |

Weighted mean. -26.06
 V_a 22.14
 V_d -14
Curvature. -28
Radial velocity. -48.6

AQUILÆ 1050.*

1907. Sept. 18.
G. M. T. 14^h 45^mObserved by J. N. TRIBBLE.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0040 | | | | 2 | 53.1850 | | | |
| $\frac{1}{2}$ | 72.8394 | .8450 | .0198 | -28.73 | 2 | 45.2417 | | | |
| 1 | 72.4318 | | | | $1\frac{1}{2}$ | 45.1800 | .2119 | .0268 | 27.98 |
| 2 | 54.7082 | | | | $\frac{1}{2}$ | 27.3503 | .3996 | .0130 | -11.28 |
| $\frac{1}{2}$ | 53.9314 | .9651 | .0044 | 5.06 | 2 | 27.2063 | | | |

Weighted mean. -22.43
 V_a -22.14
 V_d -14
Curvature. -28
Radial velocity. -45.0

* Check measurement.

SESSIONAL PAPER No. 25a

AQUILÆ 1533.

1908, May 15.
G. M. T. 20^h 54^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54 7742 | | | | 2 | 27 2579 | | | |
| $\frac{1}{2}$ | 53 9693 | 8781 | 0617 | -105 54 | $\frac{1}{2}$ | 15 3876 | 3776 | 0656 | -73 99 |
| 2 | 53 1421 | | | | 2 | 15 4086 | | | |
| 2 | 45 2974 | | | | $\frac{1}{2}$ | 11 7542 | 7520 | 0694 | -74 45 |
| $\frac{1}{2}$ | 45 1779 | 1541 | 0846 | -88 32 | 2 | 11 5091 | | | |
| $\frac{1}{2}$ | 27 3612 | 3498 | 0628 | -54 51 | | | | | |

Weighted mean..... -75 50

 V_a +26 05 V_d + 06

Curvature..... - 28

Radial velocity..... -49 7

AQUILÆ 1544.

1908, May 18.
G. M. T. 20^h 49^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54 7267 | | | | 2 | 45 2655 | | | |
| $\frac{1}{2}$ | 53 8990 | 9160 | 0538 | -61 92 | $\frac{1}{2}$ | 45 1692 | 1773 | 0614 | -64 10 |
| 2 | 53 0932 | | | | | | | | |

Weighted mean..... -62 30

 V_a +25 50 V_d + 04

Curvature..... - 28

Radial velocity..... -37 0

AQUILÆ 1576.

1908, June 3.
G. M. T. 20^h 35^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54 7369 | | | | $\frac{3}{2}$ | 45 1970 | 1900 | 0487 | -50 84 |
| 2 | 53 8906 | 8976 | 0722 | -83 10 | 1 | 11 8670 | 7770 | 0744 | -55 72 |
| 2 | 53 1029 | | | | 2 | 11 5975 | | | |
| 2 | 45 2806 | | | | | | | | |

Weighted mean..... -69 34

 V_a +21 62 V_d - 02

Curvature..... - 28

Radial velocity..... -48 0

9-10 EDWARD VII., A. 1910

 θ AQUILÆ 1583.1908. June 5.
G. M. T. 9^h 42^mObserved by T. H. PARKER.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9953 | | | | 2 | 45.2607 | | | |
| 1 | 72.8212 | .8347 | .0301 | -43.68 | 1½ | 45.1648 | .1776 | .0611 | -63.79 |
| 2 | 72.4342 | | | | 1 | 27.3467 | .3418 | .0708 | -61.45 |
| 2 | 54.7250 | | | | 2 | 27.2518 | | | |
| 2 | 53.9156 | .9287 | .0411 | -47.31 | 2 | 11.8084 | .7915 | .0699 | -44.87 |
| 2 | 53.1028 | | | | 2 | 11.5245 | | | |

Weighted mean..... - 51.35

 V_a +20.91 V_d + .04

Curvature..... - .28

Radial velocity..... - 30.7

 θ AQUILÆ 1604.1908. June 12.
G. M. T. 19^h 32^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0475 | | | | 2 | 45.2995 | | | |
| 1 | 72.8819 | .8436 | .0212 | -30.76 | 1 | 45.2281 | .2022 | .0365 | -38.11 |
| 2 | 72.4848 | | | | 1 | 37.7627 | .7265 | .0282 | -27.21 |
| 2 | 57.8373 | .7895 | .0373 | -44.91 | 2 | 37.9955 | | | |
| 1 | 57.7974 | | | | 1 | 27.4133 | .3852 | .0274 | -23.78 |
| 2 | 54.7562 | | | | 2 | 27.2746 | | | |
| 2 | 53.9652 | .9492 | .0206 | -23.71 | 1 | 11.8637 | .8173 | .0341 | -25.54 |
| 2 | 53.1298 | | | | 2 | 11.5542 | | | |

Weighted mean..... - 29.64

 V_a +18.58 V_d - .04

Curvature..... - .28

Radial velocity..... - 11.4

SESSIONAL PAPER No. 25a

AQUILÆ 1605.

1908. June 12.
G. M. T. 20^h 15^mObserved by T. H. PARKER.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|---------------|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 72.9907 | | | | 2 | 53.0714 | | | |
| $\frac{1}{2}$ | 72.8128 | 8345 | 0303 | -43.96 | 2 | 45.2430 | | | |
| 2 | 72.4181 | | | | 1 | 45.1817 | 2124 | 0263 | 27.45 |
| $\frac{1}{2}$ | 57.7935 | | | | 2 | 43.5027 | | | |
| 1 | 57.7576 | 7934 | 0334 | -40.21 | 1 | 27.3562 | 3619 | 0507 | 44.00 |
| 2 | 56.6375 | | | | 2 | 27.2410 | | | |
| 2 | 54.7069 | | | | 1 | 11.7999 | 7969 | 0545 | 41.56 |
| 1 | 53.9117 | 9500 | 0198 | -22.78 | 2 | 11.5103 | | | |

Weighted mean..... -32.99

 V_a +18.58 V_d - .04

Curvature..... - .28

Radial velocity..... -14.7

AQUILÆ 1626.

1908. June 22.
G. M. T. 18^h 35^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|----------------|-------------------------|--------------------------------|-------------------------------|-----------|---------------|-------------------------|--------------------------------|-------------------------------|-----------|
| 1 | 57.8274 | | | | $\frac{1}{2}$ | 37.7445 | 7260 | 0287 | -27.67 |
| $\frac{1}{2}$ | 57.7977 | 7957 | 0311 | -37.44 | 2 | 29.7928 | 7680 | 0629 | -55.02 |
| 2 | 54.7455 | | | | 2 | 29.6306 | | | |
| 2 | 53.9400 | 9377 | 0321 | -36.95 | 1 | 27.3906 | 3481 | 0645 | -55.98 |
| 2 | 53.1130 | | | | 2 | 27.2891 | | | |
| 2 | 45.2851 | | | | $\frac{1}{2}$ | 11.8445 | 7902 | 0612 | -58.39 |
| $1\frac{1}{2}$ | 45.2209 | 2094 | 0293 | -30.60 | 2 | 11.5615 | | | |
| 2 | 37.9777 | | | | | | | | |

Weighted mean..... -44.13

 V_a +15.01 V_d - .04

Curvature..... - .28

Radial velocity..... -29.0

9-10 EDWARD VII., A. 1910

♂ AQUILÆ 1626.*

1908. June 22.
G. M. T. 18^h 35^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|-----------------|-------------------------|--------------------------------|-------------------------------|-----------|---------------|-------------------------|--------------------------------|-------------------------------|-----------|
| 1 | 57.8369 | | | | $\frac{1}{2}$ | 37.7667 | .7262 | .0383 | -36.92 |
| 2 | 57.8165 | 8025 | .0213 | -29.26 | $\frac{1}{2}$ | 29.8124 | .7624 | .0685 | -60.90 |
| 3 | 54.7682 | | | | 2 | 29.6441 | | | |
| 3 | 53.9534 | 9294 | .0404 | -46.50 | 1 | 27.4266 | .3746 | .0380 | -32.98 |
| 3 | 53.1347 | | | | 2 | 27.3062 | | | |
| 3 | 45.3077 | | | | 2 | 11.8604 | .7864 | .0650 | -48.68 |
| 1 $\frac{1}{2}$ | 45.2463 | 2123 | .0264 | -27.56 | 2 | 11.5823 | | | |
| 2 | 38.9962 | | | | | | | | |

Weighted mean..... -41.03

 V_a +15.01 V_d +.04

Curvature..... -.28

Radial velocity..... -26.3

*Check measurement.

♂ AQUILÆ 1634.

1908. June 24.
G. M. T. 19^h 46^mObserved by W. E. HARPER.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----------------|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 57.9245 | | | | 1 | 37.8235 | .7200 | .0347 | -33.45 |
| 2 | 57.8639 | 7688 | .0580 | -69.83 | 2 | 30.6385 | | | |
| 3 | 54.8105 | | | | 1 | 29.8974 | .7819 | .0490 | -43.56 |
| 3 | 54.0327 | 9347 | .0351 | -40.40 | 1 $\frac{1}{2}$ | 27.4733 | .3561 | .0565 | -49.04 |
| 3 | 53.2094 | | | | 2 | 27.3638 | | | |
| 3 | 45.3719 | | | | 2 $\frac{1}{2}$ | 11.9231 | .8011 | .0503 | -37.67 |
| 3 | 45.2924 | 1941 | .0446 | -46.56 | 2 | 11.6292 | | | |
| 2 | 34.0650 | | | | | | | | |

Weighted mean..... -42.95

 V_a +14.12 V_d -.06

Curvature..... -.28

Radial velocity..... -29.2

SESSIONAL PAPER No. 25a

 θ AQUILÆ 1643.1908. June 26.
G. M. T. 19^h 42^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 57.8751 | | | | 2 | 38.0110 | | | |
| 2 | 57.8285 | .7742 | .0526 | -63.33 | 2 | 37.7647 | .7131 | .0416 | -40.10 |
| 2 | 54.7850 | | | | 1 | 27.4172 | .3588 | .0538 | -46.70 |
| 2 | 53.9798 | .9370 | .0328 | -37.75 | 2 | 27.3150 | | | |
| 2 | 53.1545 | | | | 3 | 11.8629 | .8040 | .0474 | -35.50 |
| 2 | 45.3226 | | | | 2 | 11.5661 | | | |
| 2 | 45.2498 | .2008 | .0379 | -39.57 | | | | | |

Weighted mean..... -42.90

 V_a +13.22 V_d - .09

Curvature..... - .28

Radial velocity..... -30.0

 θ AQUILÆ 1651.1908. June 27.
G. M. T. 18^h 45^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 57.8640 | | | | 1 | 30.8717 | .8126 | .0630 | -56.57 |
| 1 | 57.8292 | .7946 | .0322 | -38.77 | 2 | 29.6583 | | | |
| 2 | 54.7825 | | | | 1 | 29.6105 | .5510 | .0479 | -42.53 |
| 2 | 53.9715 | .9320 | .0378 | -43.51 | 1 | 27.4256 | .3390 | .0536 | -46.52 |
| 2 | 53.1535 | | | | 2 | 27.3135 | | | |
| 2 | 45.3175 | | | | 1 | 15.4903 | .4182 | .0551 | -42.65 |
| 1 | 45.2365 | .1926 | .0461 | -48.13 | 2 | 15.4707 | | | |
| 2 | 38.0075 | | | | 3 | 11.8646 | .7958 | .0556 | -41.64 |
| 1 | 37.7459 | .6973 | .0554 | -53.40 | 2 | 11.5760 | | | |
| 2 | 30.9295 | | | | | | | | |

Weighted mean..... -45.06

 V_a +12.83 V_d00

Curvature..... - .28

Radial velocity..... -32.5

9-10 EDWARD VII., A. 1913

θ AQUILÆ 1659.

1908, July 3.
G. M. T. 17^h 30^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 2 | 54.6001 | | | | 2 | 11.6263 | 11.7883 | .0631 | -47.26 |
| 2 | 53.7884 | 53.9309 | .0389 | -44.77 | 2 | 11.3448 | | | |
| 2 | 52.9687 | | | | | | | | |

Weighted mean..... -46.01

 V_s +10.32 V_d 60

Curvature..... -18

Radial velocity..... -35.9

θ AQUILÆ 1679

1908, July 8.
G. M. T. 18^h 49^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revs. | Velocity. |
|-----|-------------------------|--------------------------------|-------------------------------|-----------|-----|-------------------------|--------------------------------|-------------------------------|-----------|
| 1 | 73.1291 | | | | 2 | 45.3990 | | | |
| 1 | 72.9478 | .8298 | .0350 | -50.78 | 1 | 45.3177 | .1923 | .0464 | -48.44 |
| 1 | 72.5626 | | | | 1 | 27.4959 | .3539 | .0587 | -50.95 |
| 2 | 54.8610 | | | | 2 | 27.3903 | | | |
| 2 | 54.0581 | .9390 | .0308 | -35.45 | 1½ | 11.9233 | .7803 | .0711 | -53.25 |
| 2 | 53.2311 | | | | 2 | 11.6602 | | | |

Weighted mean..... -46.30

 V_s -8.05 V_d09

Curvature..... .28

Radial velocity..... -38.6

θ AQUILÆ 1691.

1908, July 10.
G. M. T. 19^h 30^mObserved by T. H. PARKER.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9970 | | | | 1½ | 53.9368 | .9368 | .0330 | -37.98 |
| ½ | 72.8227 | .8352 | .0296 | -42.94 | 2 | 53.1036 | | | |
| 2 | 72.4327 | | | | 2 | 45.2729 | | | |
| 2 | 57.7960 | | | | ½ | 43.1767 | .1777 | .0610 | -63.68 |
| 1 | 57.7501 | .7831 | .0463 | -55.74 | ½ | 27.3741 | .3471 | .0655 | -56.85 |
| 2 | 56.6372 | | | | 2 | 27.2739 | | | |
| 2 | 54.7314 | | | | | | | | |

Weighted mean..... -48.88

 V_s -7.14 V_d12

Curvature..... .28

Radial velocity..... -42.1

SESSIONAL PAPER No. 25a¹

AQUILÆ 1691*.

1908, July 10,
G. M. T. 19^h 30^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0001 | | | | 1½ | 53.9446 | .9446 | .0252 | -29.00 |
| 1 | 72.8210 | .8277 | .0371 | -53.83 | 2 | 53.1121 | | | |
| 1 | 72.4443 | | | | 2 | 45.2831 | | | |
| 2 | 57.8282 | | | | 1½ | 45.1971 | .1874 | .0513 | -53.56 |
| 1 | 57.7688 | .7700 | .0568 | -68.39 | 1½ | 27.4088 | .3658 | .0468 | -39.62 |
| 2 | 54.7417 | | | | 2 | 27.2902 | | | |

Weighted mean..... -47.79

 V_a +7.14 V_d -12

Curvature..... -28

* Check measurement.

Radial velocity..... -41.0

AQUILÆ 1696.

1908, July 11,
G. M. T. 19^h 10^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8543 | | | | 1½ | 45.2351 | .1991 | .0396 | -41.34 |
| 1 | 57.8215 | .7968 | .0390 | -36.12 | 2 | 29.6333 | | | |
| 2 | 54.7744 | | | | 1 | 29.6020 | .5676 | .0313 | -27.54 |
| 2 | 53.9587 | .9274 | .0424 | -48.80 | 2 | 11.8235 | .7982 | .0532 | -39.85 |
| 2 | 53.1422 | | | | 2 | 11.5325 | | | |
| 2 | 45.3096 | | | | | | | | |

Weighted mean..... -40.40

 V_a +6.60 V_d -12

Curvature..... -28

Radial velocity..... -34.2

9-10 EDWARD VII., A. 1910

 θ AQUILÆ 1704.1908, July 13.
G. M. T. 19^h 37^m.Observed by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73.0441 | | | | 2 | 53.1318 | | | |
| $\frac{1}{2}$ | 72.8698 | .8565 | .0083 | -12.05 | 2 | 45.3027 | | | |
| 1 | 72.4491 | | | | 1 | 45.2546 | .2156 | .0231 | -24.12 |
| 2 | 57.8483 | | | | $\frac{1}{2}$ | 27.4155 | .3555 | .0561 | -48.69 |
| $\frac{1}{2}$ | 57.8073 | .7883 | .0385 | -46.35 | 2 | 27.3060 | | | |
| 2 | 54.7666 | | | | $1\frac{1}{2}$ | 11.8718 | .7958 | .0556 | -41.64 |
| 2 | 53.9556 | .9296 | .0402 | -46.27 | 2 | 11.5838 | | | |

Weighted mean. -38.78

 V_a +5.77 V_d - .16

Curvature..... - .24

Radial velocity..... -33.5

 θ AQUILÆ 1705.1908, July 14.
G. M. T. 18^h 19^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73.0051 | | | | 2 | 45.2705 | | | |
| 1 | 72.8307 | .8351 | .0297 | -43.69 | 2 | 45.2015 | .2045 | .0342 | -35.70 |
| 1 | 72.4410 | | | | $1\frac{1}{2}$ | 27.3918 | .3786 | .0430 | -37.32 |
| 2 | 54.7316 | | | | 2 | 27.2622 | | | |
| 2 | 53.9435 | .9505 | .0193 | -22.21 | 2 | 11.8489 | .8199 | .0315 | -23.58 |
| 2 | 53.1072 | | | | 2 | 11.5364 | | | |

Weighted mean..... -30.83

 V_a +5.34 V_d 00

Curvature..... - .28

Radial velocity..... -25.8

SESSIONAL PAPER No. 25a

 θ AQUILÆ 1716.1908, July 15.
G. M. T. 19^h 24^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0426 | | | | 2 | 45.3046 | | | |
| $\frac{1}{2}$ | 72.8798 | .8475 | .0173 | -25.10 | 1 | 45.2469 | .2159 | .0228 | 23.80 |
| 1 | 72.4764 | | | | 2 | 29.6384 | | | |
| | 57.8582 | | | | $1\frac{1}{2}$ | 29.6106 | .5716 | .0273 | 24.22 |
| | 57.8243 | .7943 | .0313 | 37.68 | $1\frac{1}{2}$ | 27.4356 | .3871 | .0255 | 22.15 |
| 2 | 54.7774 | | | | 2 | 27.2951 | | | |
| 2 | 53.9873 | .9543 | .0155 | 17.84 | $1\frac{1}{2}$ | 11.8697 | .8197 | .0317 | -23.74 |
| 2 | 53.1427 | | | | 2 | 11.5523 | | | |

Weighted mean..... -23.88

 V_a +4.86 V_d - .16

Curvature..... - .28

Radial velocity..... -19.5

 θ AQUILÆ 1727.1908, July 25.
G. M. T. 16^h 29^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0229 | | | | 2 | 45.2811 | | | |
| 1 | 72.8498 | .8385 | .0263 | -38.16 | 2 | 45.2157 | .2082 | .0305 | 31.84 |
| 1 | 72.4507 | | | | $\frac{1}{2}$ | 27.3982 | .3715 | .0411 | 35.67 |
| 2 | 54.7506 | | | | 2 | 27.2733 | | | |
| 2 | 53.9420 | .9323 | .0375 | 43.16 | $2\frac{1}{2}$ | 11.8282 | .8011 | .0503 | -37.67 |
| 2 | 53.1227 | | | | 2 | 11.5343 | | | |

Weighted mean..... -37.52

 V_a + .25 V_d + .04

Curvature..... - .28

Radial velocity..... -37.5

9-10 EDWARD VII., A. 1910

♄ AQUILÆ 1730.

1908, July 26.
G. M. T. 17^h 38^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0205 | | | | 2 | 45.2945 | | | |
| 1 | 72.8350 | 8244 | 0404 | - 38.62 | 1 1/2 | 45.2203 | 1994 | 0393 | 41.02 |
| 2 | 72.4551 | | | | 1 | 27.4096 | 3642 | 0484 | 42.01 |
| 2 | 57.8380 | | | | 2 | 27.2920 | | | |
| 2 | 54.7570 | | | | 2 | 11.8572 | 8032 | 0482 | - 36.10 |
| 2 | 53.9564 | 9427 | 0271 | 31.19 | 2 | 11.5612 | | | |
| 2 | 53.1243 | | | | | | | | |

Weighted mean..... - 38.20

 V_a 24 V_d 11

Curvature..... 28

Radial velocity..... 38.8

♄ AQUILÆ 1731.

1908, July 26.
G. M. T. 18^h 07^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8287 | | | | 1 1/2 | 45.1997 | 1980 | 0407 | 42.49 |
| 1 | 57.7975 | 7982 | 0286 | - 41.50 | 1 | 27.3970 | 3792 | 0334 | 29.00 |
| 2 | 54.7400 | | | | 2 | 27.2644 | | | |
| 2 | 53.9365 | 9368 | 0330 | 38.00 | 1 | 11.8173 | 7869 | 0645 | - 48.31 |
| 2 | 53.1122 | | | | 2 | 11.5376 | | | |
| 2 | 45.2753 | | | | | | | | |

Weighted mean..... - 39.83

 V_a 24 V_d 11

Curvature..... 28

Radial velocity..... - 40.5

AQUILAE 1732.

1908, July 27.
G. M. T. 18^h 15^m

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------------------------|
| 2 | 57 6860 | | | | 1 | 45 6540 | 2035 | 0352 | 36 75 |
| $\frac{1}{2}$ | 57 6422 | 7856 | 0412 | -49 60 | 2 | 29 4545 | | | |
| 2 | 54 5924 | | | | $\frac{1}{2}$ | 29 4224 | 5668 | 0321 | 28 47 |
| 2 | 53 7915 | 9405 | 0293 | 33 72 | $\frac{1}{2}$ | 11 6850 | 8415 | 0099 | - 7 41 |
| 2 | 52 9636 | | | | 2 | 11 3507 | | | |
| 2 | 45 1239 | | | | | | | | |
| | | | | | | | | | Weighted mean..... - 32 23 |
| | | | | | | | | | V _a - 73 |
| | | | | | | | | | V _d - 12 |
| | | | | | | | | | Curvature..... - 28 |
| | | | | | | | | | Radial velocity..... - 33 4 |

AQUILAE 1733.

1908. July 27.
G. M. T. 20^h 10^m

Observed by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------------------------|
| 10 | 57.8173 | | | | 1 | 53.9094 | .9241 | .0457 | — 52.60 |
| 10 | 57.7872 | 7993 | 0273 | — 32.87 | 2 | 53.1007 | | | |
| 10 | 54.7239 | | | | | | | | |
| | | | | | | | | | Weighted mean..... — 39.45 |
| | | | | | | | | | V_a — 73 |
| | | | | | | | | | V_d — 24 |
| | | | | | | | | | Curvature..... — 28 |
| | | | | | | | | | Radial velocity..... — 40.7 |

θ AQUILAE 1735.

1908. July 28.
G. M. T. 17^h 49^m

Observed by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|----------------------------|
| 2 | 57 7810 | | | | 2 | 37 9067 | | | |
| 1 | 57 7302 | 7786 | 0482 | -57 91 | $\frac{1}{2}$ | 37 6760 | 7285 | 0262 | 25 26 |
| 2 | 54 6993 | | | | 2 | 29 5479 | | | |
| 2 | 53 8959 | 9391 | 0307 | 35 33 | 1 | 29 4960 | 5470 | 0519 | 46 14 |
| 2 | 53 0681 | | | | $\frac{1}{2}$ | 27 3178 | 3688 | 0438 | -38 02 |
| 2 | 45 2233 | | | | 2 | 27 1956 | | | |
| 1 | 45 1554 | 2057 | 0330 | 34 45 | | | | | |
| | | | | | | | | | Weighted mean..... -40 13 |
| | | | | | | | | | V_{α} -1 20 |
| | | | | | | | | | V_{δ} -10 |
| | | | | | | | | | Curvature..... -28 |
| | | | | | | | | | Radial velocity..... -42 7 |

9-10 EDWARD VII., A. 1910

 θ AQUILÆ 1736.1908, July 28.
G. M. T. 18^h 08^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7033 | ..... | ..... | ..... | 2 | 37.9039 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 53.9012 | .9418 | .0280 | -32.23 | 1 $\frac{1}{2}$ | 37.6815 | .7368 | .0179 | -17.25 |
| 2 | 53.0681 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... -28.48

 V_d -1.20 V_d -12

Curvature..... -28

Radial velocity..... -30.1

 θ AQUILÆ 1747.1908, July 30.
G. M. T. 17^h 47^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0586 | ..... | ..... | ..... | 2 | 45.2720 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 72.8916 | .8438 | .0210 | -30.47 | 1 $\frac{1}{2}$ | 45.1954 | .1970 | .0417 | 43.53 |
| 2 | 72.4899 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.3662 | .3783 | .0343 | 29.77 |
| 2 | 54.7537 | ..... | ..... | ..... | 2 | 27.2345 | ..... | ..... | ..... |
| 2 | 53.9640 | .9538 | .0160 | 18.42 | 1 $\frac{1}{2}$ | 11.7805 | .8237 | .0287 | -21.50 |
| 2 | 53.1210 | ..... | ..... | ..... | 2 | 11.4640 | ..... | ..... | ..... |

Weighted mean..... -28.60

 V_d -2.13 V_d -10

Curvature..... -28

Radial velocity..... -31.1

 θ AQUILÆ 1755.1908, July 31.
G. M. T. 17^h 52^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 57.9005 | ..... | ..... | ..... | 2 | 29.6870 | ..... | ..... | ..... |
| 1 | 57.8680 | .7968 | .0300 | -36.12 | 1 | 27.4678 | .3771 | .0355 | 30.81 |
| 2 | 45.3421 | ..... | ..... | ..... | 2 | 27.3373 | ..... | ..... | ..... |
| 1 | 45.2829 | .2144 | .0245 | 25.37 | 1 | 11.8987 | .8159 | .0355 | -26.59 |
| 1 $\frac{1}{2}$ | 29.6625 | .5744 | .0245 | 21.78 | 2 | 11.5900 | ..... | ..... | ..... |

Weighted mean..... -27.56

 V_d -2.59 V_d -11

Curvature..... -28

Radial velocity..... -30.5

SESSIONAL PAPER No. 25a

 θ AQUILÆ 1756.1908, July 31.
G. M. T. 18^h 19^mObserved by J. W. E. HARPER.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.1090 | | | | 2 | 45.3718 | | | |
| $\frac{1}{2}$ | 72.9433 | .8464 | .0184 | -26.70 | 2 | 45.3132 | .2150 | .0237 | 24.74 |
| 2 | 72.5395 | | | | $1\frac{1}{2}$ | 27.5107 | .3881 | .0245 | 21.27 |
| 2 | 54.8279 | | | | 2 | 27.3692 | | | |
| $1\frac{1}{2}$ | 54.9425 | .9526 | .0172 | 19.80 | 2 | 11.9418 | .8239 | .0275 | -20.60 |
| 2 | 53.2657 | | | | 2 | 11.6251 | | | |

Weighted mean..... -23.42
 V_a -2.59
 V_d15
Curvature..... -28
Radial velocity..... -26.4

 θ AQUILÆ 1762.1908, Aug. 5.
G. M. T. 14^h 50^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.9445 | | | | 2 | 37.9735 | | | |
| $\frac{1}{2}$ | 72.9019 | .8689 | .0041 | +5.94 | $\frac{1}{2}$ | 37.8169 | .8026 | .0479 | 46.17 |
| 2 | 72.4763 | | | | $1\frac{1}{2}$ | 30.9439 | .9214 | .0458 | 41.12 |
| 2 | 54.7639 | | | | 2 | 30.8932 | | | |
| 1 | 54.0333 | .0153 | .0455 | 52.37 | 1 | 27.4672 | .4477 | .0351 | 30.46 |
| 2 | 54.0467 | | | | 2 | 27.2659 | | | |
| 2 | 53.1283 | | | | 1 | 11.9221 | .9161 | .0647 | +48.46 |
| 2 | 45.2915 | | | | 2 | 11.5123 | | | |
| $1\frac{1}{2}$ | 45.2840 | .2661 | .0274 | 28.60 | | | | | |

Weighted mean..... +39.69
 V_a -4.91
 V_d +.09
Curvature..... -28
Radial velocity..... +34.6

9-10 EDWARD VII., A. 1910

 θ AQUILÆ 1766.1908, Aug. 5.
G. M. T. 16^h 29^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7555 | ..... | ..... | ..... | 2 | 37 9696 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 54 0175 | 0058 | 0300 | -41 44 | 1 | 37 8146 | 8042 | 0495 | 47 72 |
| 2 | 53 1220 | ..... | ..... | ..... | 2 | 11 9212 | 9096 | 0582 | -43 59 |
| 2 | 45 2833 | ..... | ..... | ..... | 2 | 11 5188 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 45 2691 | 2594 | 0207 | 21 61 | | | | | |

Weighted mean -38 25

 V_a 4 91 V_d 02

Curvature 28

Radial velocity +33 0

 θ AQUILÆ 1767.1908, Aug. 5.
G. M. T. 17^h 18^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7650 | ..... | ..... | ..... | 1 | 37 7837 | 7738 | 0191 | 16 98 |
| 1 | 54 0152 | 9958 | 0260 | +29 93 | $\frac{1}{2}$ | 27 4480 | 4226 | 0100 | 8 68 |
| 2 | 53 1277 | ..... | ..... | ..... | 2 | 27 2720 | ..... | ..... | ..... |
| 2 | 45 2725 | 2545 | 0158 | 16 50 | $\frac{1}{2}$ | 11 9180 | 8062 | 0454 | +34 00 |
| 2 | 45 2916 | ..... | ..... | ..... | 2 | 11 5284 | ..... | ..... | ..... |
| 2 | 37 9791 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean +21 19

 V_a 4 91 V_d 09

Curvature 28

Radial velocity +15 9

 θ AQUILÆ 1769.1908, Aug. 5.
G. M. T. 18^h 48^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73 0800 | ..... | ..... | ..... | 2 | 54 0263 | 9743 | 0045 | +5 18 |
| $\frac{1}{2}$ | 72 9310 | 8618 | 0030 | -4 25 | 2 | 53 1625 | ..... | ..... | ..... |
| 2 | 72 5112 | ..... | ..... | ..... | 2 | 45 3224 | ..... | ..... | ..... |
| 2 | 54 7953 | ..... | ..... | ..... | 1 | 45 2968 | 2476 | 0089 | +9 29 |

Weighted mean +5 00

 V_a 4 91 V_d 19

Curvature 28

Radial velocity -0 4

SESSIONAL PAPER No. 25a

 θ AQUILÆ 1776.1908, Aug. 7.
G. M. T. 17^hObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0105 | | | | 2 | 53.1270 | | | |
| $\frac{1}{2}$ | 72.8287 | .8311 | .0337 | -48.90 | 2 | 45.2947 | | | |
| 2 | 72.4303 | | | | 1 | 45.2297 | .1994 | .0393 | 41.03 |
| 2 | 54.7527 | | | | 2 | 11.8727 | .8100 | .0414 | -39.64 |
| $1\frac{1}{2}$ | 53.9542 | .9413 | .0285 | 32.80 | 2 | 11.5703 | | | |

Weighted mean..... -35.19

 V_a -5.87 V_d08

Curvature..... .28

Radial velocity..... -41.4

 θ AQUILÆ 1777.1908, Aug. 7.
G. M. T. 17^h 45^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0173 | | | | 2 | 45.3157 | | | |
| $\frac{1}{2}$ | 72.8345 | .8281 | .0367 | -53.25 | 1 | 45.2536 | .2117 | .0270 | 28.19 |
| 2 | 72.4482 | | | | 1 | 27.4414 | .3756 | .0370 | 32.12 |
| 2 | 57.8521 | | | | 2 | 27.3125 | | | |
| 1 | 57.8257 | .8028 | .0240 | 28.90 | $1\frac{1}{2}$ | 11.9090 | .8208 | .0306 | 22.64 |
| 2 | 54.7686 | | | | 2 | 11.5960 | | | |
| $1\frac{1}{2}$ | 53.9656 | .9371 | .0327 | 37.64 | 1 | 29.8450 | .7881 | .0428 | -38.05 |
| 2 | 53.1442 | | | | 2 | 29.6558 | | | |

Weighted mean..... -32.57

 V_a -5.87 V_d -14

Curvature..... .28

Radial velocity..... -38.9

 θ AQUILÆ 1789.1908, Aug. 17.
G. M. T. 18^h 18^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| $1\frac{1}{2}$ | 57.8885 | .8148 | .0120 | 13.81 | 2 | 45.3395 | | | |
| 2 | 57.9031 | | | | 1 | 45.2972 | .2313 | .0074 | 7.72 |
| 2 | 54.8125 | | | | 2 | 38.0187 | | | |
| 2 | 34.0320 | .9614 | .0084 | 9.67 | 1 | 37.8079 | .7484 | .0063 | -6.07 |
| 2 | 53.1826 | | | | | | | | |

Weighted mean..... -9.78

 V_a -10.39 V_d21

Curvature..... .28

Radial velocity..... -20.7

9-10 EDWARD VII., A. 1910

6 AQUILÆ 1789.*

1908. Aug. 17.
G. M. T. 18^h 18^m.Observed by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8769 | | | | 1 | 45.2667 | .2271 | .0116 | 12.11 |
| 1 | 57.8580 | .8105 | .0163 | -20.15 | 2 | 37.9966 | | | |
| 2 | 54.7899 | | | | 1 | 37.7900 | .7526 | .0021 | 2.02 |
| 2 $\frac{1}{2}$ | 54.0078 | .9618 | .0080 | 9.21 | $\frac{1}{2}$ | 29.8666 | .8260 | .0049 | -4.36 |
| 2 | 53.1557 | | | | 2 | 29.6395 | | | |
| 2 | 45.3130 | | | | | | | | |

Weighted mean..... - 9.91

 V_a -10.39 V_d - .21

Curvature..... - .28

Radial velocity..... -20.8

* Inadvertently remeasured.

8 AQUILÆ 1794*.

1908. Aug. 19.
G. M. T. 16^h 45^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 111.6998 | | | | 2 | 68.7143 | | | |
| $\frac{1}{2}$ | 111.3210 | .1330 | .0193 | -11.19 | 2 | 63.3902 | | | |
| 2 | 110.2983 | | | | 4 | 61.2072 | .2159 | .0286 | 11.75 |
| 2 | 71.8920 | | | | 2 | 60.3880 | | | |
| 1 | 71.8568 | .8664 | .0392 | 17.29 | 2 | 36.0921 | | | |
| $\frac{1}{2}$ | 69.5153 | .5373 | .0155 | 6.73 | $\frac{1}{2}$ | 35.9450 | .9631 | .0427 | -14.90 |

Weighted mean..... -12.41

 V_a -11.21 V_d - .12

Curvature..... - .28

Radial velocity..... -24.0

* Plate made with three-prism spectrograph.

SESSIONAL PAPER No. 25a

♂ AQUILÆ 1790.

1908. Aug. 20.
G. M. T. 15^h 15^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9899 | | | | 2 | 45.2480 | .2644 | .0257 | +26.83 |
| $\frac{1}{2}$ | 72.8610 | .8811 | .0163 | +23.65 | 2 | 37.9470 | | | |
| 2 | 72.4241 | | | | 1 | 37.7533 | .7655 | .0168 | +10.41 |
| 2 | 57.8022 | | | | 1 | 29.6165 | .6164 | .0175 | +15.56 |
| 1 | 57.8095 | .8387 | .0119 | -14.33 | 2 | 29.5900 | | | |
| 2 | 54.7204 | | | | $\frac{1}{2}$ | 27.4145 | .4051 | .0075 | -6.51 |
| 2 | 53.9533 | .9751 | .0053 | +6.11 | 2 | 27.2560 | | | |
| 2 | 53.0808 | | | | $\frac{1}{2}$ | 11.8457 | .8229 | .0185 | -13.90 |
| 2 | 45.2572 | | | | 2 | 11.5390 | | | |

Weighted mean +12.45

 V_a -11.63 V_d 00

Curvature - .28

Radial velocity +0.4

♂ AQUILÆ 1800.

1908. Aug. 20.
G. M. T. 15^h 47^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0033 | | | | $1\frac{1}{2}$ | 45.2531 | .2537 | .0150 | +15.66 |
| $\frac{1}{2}$ | 72.8582 | .8648 | .0000 | 0.00 | 1 | 27.4586 | .4290 | .0164 | +14.23 |
| 2 | 72.4383 | | | | 2 | 27.2762 | | | |
| 2 | 54.7375 | | | | 2 | 11.9005 | .8700 | .0186 | +13.93 |
| 1 | 53.9710 | .9747 | .0049 | +5.64 | 1 | 59.8045 | | | |
| 2 | 53.1090 | | | | 1 | 59.6690 | .6736 | .0009 | -1.23 |
| 2 | 45.2729 | | | | | | | | |

Weighted mean +10.00

 V_a -11.63 V_d -.05

Curvature -.28

Radial velocity -2.0

9-10 EDWARD VII., A. 1910

AQUILÆ 1801.

1908, Aug. 20.
G. M. T. 16^h 42^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7354 | ..... | ..... | ..... | 1 | 29.6294 | .6194 | .0205 | 18.24 |
| 2 | 53.9787 | .9881 | .0183 | +21.06 | 2 | 29.6095 | ..... | ..... | ..... |
| 2 | 53.0997 | ..... | ..... | ..... | 1 | 27.4557 | .4361 | .0235 | 20.39 |
| 2 | 45.2665 | ..... | ..... | ..... | 2 | 27.2662 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 45.2453 | 2524 | .0137 | 14.30 | 1 $\frac{1}{2}$ | 11.8962 | .8614 | .0100 | +7.49 |
| 2 | 29.9322 | ..... | ..... | ..... | 2 | 11.5362 | ..... | ..... | ..... |
| 1 | 29.8670 | .8575 | .0266 | 23.67 | | | | | |

Weighted mean..... +18.52

 V_a -11.63 V_d -12

Curvature..... -28

Radial velocity..... -6.5

AQUILÆ 1807.

1908, Aug. 21.
G. M. T. 13^h 57^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0196 | ..... | ..... | ..... | 2 $\frac{1}{2}$ | 45.3011 | .2689 | .0302 | 31.52 |
| 1 | 72.9000 | .8880 | .0232 | -33.66 | 2 | 29.6480 | ..... | ..... | ..... |
| 2 | 72.4635 | ..... | ..... | ..... | 1 | 29.9315 | .8830 | .0521 | 46.32 |
| 2 | 54.7685 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.4940 | .4406 | .0289 | 24.30 |
| 1 $\frac{1}{2}$ | 54.0400 | .0124 | .0425 | 49.03 | 2 | 27.3002 | ..... | ..... | ..... |
| 2 | 53.1406 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 11.9607 | .8964 | .0410 | +30.71 |
| 2 | 45.3058 | ..... | ..... | ..... | 2 | 11.5717 | ..... | ..... | ..... |

Weighted mean..... +41.42

 V_a -12.04 V_d -11

Curvature..... -28

Radial velocity..... +28.7

SESSIONAL PAPER No. 25a

♄ AQUILÆ 1808.

1908. Aug. 21.
G. M. T. 14^h 32^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72 9966 | | | | 2 | 45 2823 | | | |
| $\frac{1}{10}$ | 72 8700 | 8818 | 0170 | +24.67 | 1 | 45 2779 | 2692 | 0305 | 31.84 |
| 2 | 72 4343 | | | | 2 | 37 9791 | | | |
| $\frac{1}{10}$ | 57 8783 | 8783 | 6515 | 62.00 | 1 | 37 8677 | 7978 | 0431 | 41.55 |
| 2 | 57 8294 | | | | $\frac{1}{2}$ | 27 4542 | 4226 | 0100 | 8.68 |
| 2 | 54 7475 | | | | 2 | 27 2782 | | | |
| $\frac{1}{2}$ | 54 0150 | 0110 | 0412 | 47.42 | 1 | 11 9453 | 9014 | 0500 | +37.45 |
| 2 | 53 1145 | | | | 2 | 11 5512 | | | |

Weighted mean..... +38.27
 V_a -12.04
 V_d + .06
Curvature..... .28

Radial velocity..... +26.0

♄ AQUILÆ 1810.

1908. Aug. 21.
G. M. T. 15^h 28^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7201 | | | | 2 | 29 5981 | | | |
| 3 | 53 9840 | 0054 | 0356 | +40.97 | $\frac{1}{10}$ | 27 4505 | 4459 | 0333 | 28.90 |
| $\frac{1}{10}$ | 53 0910 | | | | 2 | 27 2512 | | | |
| 2 | 45 2620 | | | | $\frac{1}{2}$ | 11 8967 | 8831 | 0317 | +23.74 |
| 2 | 45 2323 | 2659 | 0272 | 28.40 | 2 | 11 5218 | | | |
| $\frac{1}{2}$ | 29 8745 | 8753 | 0411 | 39.47 | | | | | |

Weighted mean..... +34.73
 V_a -12.04
 V_d - .02
Curvature..... .28

Radial velocity..... +22.4

9-10 EDWARD VII., A. 1910

 θ AQUILÆ 1811.1908. Aug. 22.
G. M. T. 15^h 29^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72·9587 | ..... | ..... | ..... | 2 | 45·2600 | ..... | ..... | ..... |
| 2 | 72·8387 | ·8901 | ·0253 | +36·71 | 1 | 45·2775 | ·2911 | ·0524 | 54·70 |
| 2 | 72·3930 | ..... | ..... | ..... | 1 | 27·4871 | ·4380 | ·0454 | 39·43 |
| 2 | 54·7138 | ..... | ..... | ..... | 2 | 27·2762 | ..... | ..... | ..... |
| 2 | 53·9876 | ·0134 | ·0436 | 50·18 | 2 | 11·9679 | ·9170 | ·0656 | +49·13 |
| 2 | 53·0885 | ..... | ..... | ..... | 2 | 11·5387 | ..... | ..... | ..... |

Weighted mean..... +47·86

 V_a -12·50 V_d -·03

Curvature..... -·28

Radial velocity..... +35·0

 θ AQUILÆ 1812.1908. Aug. 22.
G. M. T. 15^h 56^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72·9892 | ..... | ..... | ..... | 2 | 45·2531 | ..... | ..... | ..... |
| 1 | 72·8897 | ·9116 | ·0468 | +67·91 | 1 | 45·2633 | ·2838 | ·0451 | 47·08 |
| 2 | 72·4190 | ..... | ..... | ..... | 3 | 27·5378 | ·4728 | ·0602 | 52·25 |
| 2 | 54·7430 | ..... | ..... | ..... | 2 | 27·3121 | ..... | ..... | ..... |
| 1 | 54·0200 | ·0182 | ·0484 | 55·71 | 2 | 12·0073 | ·9163 | ·0649 | +48·61 |
| 2 | 53·1145 | ..... | ..... | ..... | 2 | 11·5988 | ..... | ..... | ..... |

Weighted mean..... +52·03

 V_a -12·50 V_d -·08

Curvature..... -·28

Radial velocity..... +39·1

SESSIONAL PAPER No. 25a

 θ AQUILÆ 1813.1908. Aug. 22.
G. M. T. 16^h 21^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9817 | | | | 2 | 45.2804 | | | |
| 1 | 72.8487 | .8779 | .0131 | +19.01 | 1 | 45.2807 | .2739 | .0352 | 36.75 |
| 2 | 72.4145 | | | | 1 | 29.7215 | .6886 | .0897 | 79.74 |
| 2 | 57.8665 | .8839 | .0571 | 68.75 | 2 | 29.6318 | | | |
| 2 | 57.8120 | | | | 1 | 27.4825 | .4387 | .0221 | 19.18 |
| 2 | 54.7342 | | | | 2 | 27.2904 | | | |
| 1 | 54.0630 | .0118 | .0420 | 48.34 | 2½ | 11.9879 | .9218 | .0704 | +52.73 |
| 2 | 53.1022 | | | | 2 | 11.5733 | | | |

Weighted mean..... +47.73

 V_a -12.50 V_d -11

Curvature..... -28

Radial velocity..... +34.8

 θ AQUILÆ 1814.1908. Aug. 23.
G. M. T. 15^h 48^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0102 | | | | 2 | 53.1312 | | | |
| 1 | 72.8535 | .8541 | .0103 | -14.94 | 2 | 45.3009 | | | |
| 2 | 72.4415 | | | | 1 | 45.2574 | .2301 | .0686 | 8.98 |
| 2 | 57.8425 | | | | 1 | 27.4527 | .3856 | .0270 | 23.44 |
| 1 | 57.8224 | .8093 | .0175 | 21.07 | 2 | 27.3137 | | | |
| 2 | 54.7607 | | | | 2 | 11.9226 | .8286 | .0228 | -17.08 |
| 2 | 53.9771 | .9581 | .0117 | 13.47 | 2 | 11.6012 | | | |

Weighted mean..... -16.27

 V_a -12.95 V_d -08

Curvature..... -28

Radial velocity..... -29.6

9-10 EDWARD VII., A. 1910

θ AQUILÆ 1815.

1908. Aug. 23.
G. M. T. 16^h 18^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73·0307 | | | | 1½ | 45·2666 | ·2192 | ·0195 | 20·86 |
| 1½ | 72·8645 | ·8438 | ·0210 | 30·47 | 2 | 38·0157 | | | |
| 2 | 72·4655 | | | | 1½ | 37·7910 | ·7348 | ·0199 | 19·18 |
| 2 | 57·8525 | | | | 2 | 29·6320 | ·5663 | ·0386 | 29·87 |
| 1½ | 57·8167 | ·7936 | ·0332 | 39·97 | 2 | 29·6646 | | | |
| 2 | 54·7766 | | | | 1½ | 27·4726 | ·4035 | ·0691 | 7·90 |
| 1½ | 54·0057 | ·9686 | ·0012 | 1·38 | 2 | 27·3157 | | | |
| 2 | 53·1516 | | | | 2 | 11·9125 | ·8329 | ·0185 | -13·86 |
| 2 | 45·3210 | | | | 2 | 11·5870 | | | |

Weighted mean..... -19·30

V_a..... -12·95V_d..... -·10

Curvature..... -·28

Radial velocity..... -32·6

θ AQUILÆ 1822.

1908. Aug. 24.
G. M. T. 16^h 51^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73·0206 | | | | 3 | 45·2872 | | | |
| 1 | 72·8615 | ·8505 | ·0143 | -20·75 | 1½ | 45·2305 | ·2169 | ·0218 | 22·76 |
| 2 | 72·4567 | | | | 2 | 37·9830 | | | |
| 2 | 57·8371 | | | | 1 | 37·7598 | ·7360 | ·0187 | 18·03 |
| 1 | 57·8167 | ·8090 | ·0178 | 21·43 | 1 | 27·4280 | ·3884 | ·0232 | 20·14 |
| 2 | 54·7477 | | | | 2 | 27·2862 | | | |
| 2 | 53·9567 | ·9471 | ·0227 | 26·13 | 2½ | 11·8689 | ·8272 | ·0242 | -18·12 |
| 2 | 53·1254 | | | | 2 | 11·5489 | | | |

Weighted mean..... -21·20

V_a..... -13·40V_d..... -·16

Curvature..... -·28

Radial velocity..... -35·0

SESSIONAL PAPER No. 25a

 θ AQUILÆ 1835.1908. Aug. 27.
G. M. T. 14^h 02^mObserved by J. B. CANNON.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73 0129 | | | | 2 | 45 2808 | | | |
| $\frac{1}{2}$ | 72 8466 | 8451 | 0197 | -28.58 | $1\frac{1}{2}$ | 45 2153 | 2081 | 0306 | 31.95 |
| 1 | 72 4418 | | | | 1 | 27 3961 | 3662 | 0536 | 45.42 |
| 2 | 54 7388 | | | | 2 | 27 2768 | | | |
| 1 | 53 9403 | 9413 | 0285 | 32.80 | 1 | 11 8524 | 8125 | 0389 | -29.14 |
| 2 | 53 1131 | | | | 2 | 11 5472 | | | |

Weighted mean. -33.92
 V_a -14.56
 V_d - .06
 Curvature .. - .28

Radial velocity..... -48.8

 θ AQUILÆ 1864.1908. Sept. 3.
G. M. T. 16^h 17^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73 0322 | | | | $1\frac{1}{2}$ | 45 2772 | 2317 | 0070 | 7.33 |
| 1 | 72 8740 | 8526 | 0122 | 17.73 | 2 | 29 9672 | | | |
| 2 | 72 4635 | | | | $1\frac{1}{2}$ | 29 8930 | 8174 | 0135 | 12.08 |
| 2 | 57 8686 | | | | 1 | 29 6537 | 5860 | 0129 | 11.49 |
| $\frac{1}{2}$ | 57 8351 | 7959 | 0309 | 37.26 | 2 | 29 6787 | | | |
| 2 | 54 7801 | | | | 1 | 27 4700 | 3816 | 0310 | 27.03 |
| $2\frac{1}{2}$ | 54 6605 | 9616 | 0082 | 9.46 | 2 | 27 3355 | | | |
| 2 | 53 1516 | | | | $1\frac{1}{2}$ | 11 9352 | 8254 | 0260 | -19.58 |
| 2 | 45 3191 | | | | 2 | 11 6205 | | | |

Weighted mean. -14.96
 V_a -17.37
 V_d 16
 Curvature - .28

Radial velocity..... -32.8

9-10 EDWARD VII., A. 1910

 θ AQUILÆ 1864.*1908, Sept. 3.
G. M. T. 16^h 17^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72° 9854 | | | | 2 | 45 2737 | | | |
| $\frac{1}{2}$ | 72° 8295 | 8541 | 0107 | -15.52 | 1 | 45 2348 | 2347 | 0040 | 4.16 |
| 2 | 72° 4198 | | | | $\frac{1}{2}$ | 29° 8500 | 8107 | 0202 | 17.80 |
| 2 | 57° 8199 | | | | 2 | 30° 9097 | | | |
| $\frac{1}{2}$ | 57° 8027 | 8122 | 0173 | 10.70 | 1 | 29° 6055 | 5660 | 0181 | 16.05 |
| 2 | 54° 7376 | | | | 1 | 11° 8883 | 8258 | 0256 | -19.17 |
| $\frac{1}{2}$ | 53° 9573 | 9518 | 0080 | 9.20 | 2 | 11° 5697 | | | |
| 2 | 53° 1065 | | | | | | | | |

Weighted mean -15.34

 V_a -17.37 V_d -16

Curvature -28

Radial velocity -33.1

* Independent measurement.

 θ AQUILÆ 1875.1908, Sept. 8.
G. M. T. 12^h 42^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73 0022 | | | | 2 | 45 2770 | | | |
| $\frac{1}{2}$ | 72° 8789 | 8850 | 0202 | +29.31 | $\frac{1}{2}$ | 45° 3101 | 3067 | 0680 | 70.99 |
| 1 | 72° 4437 | | | | 1 | 27° 5014 | 4694 | 0668 | 49.34 |
| 2 | 54° 7440 | | | | 2 | 27° 2778 | | | |
| 1 | 54° 0395 | 0356 | 0058 | 75.73 | 1 | 12° 0038 | 9496 | 0982 | -73.55 |
| 2 | 53° 1178 | | | | 2 | 11° 5614 | | | |

Weighted mean +67.85

 V_a -17.08 V_d -09

Curvature -28

Radial velocity -50.6

SESSIONAL PAPER No. 25a

 θ AQUILÆ 1875*.1908. Sept. 8.
G. M. T. 12^h 42^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|--------------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7676 | | | | 2 | 29.6453 | | | |
| 2 | 54.0485 | .0218 | .0520 | +59.85 | 1½ | 29.7430 | .6966 | .0977 | 86.66 |
| 2 | 53.1396 | | | | 1 | 12.0185 | .9417 | .0903 | +67.63 |
| 2 | 45.3024 | | | | 2 | 11.5840 | | | |
| 1½ | 45.3295 | .3907 | .0620 | 64.73 | | | | | |
| Weighted mean..... | | | | | | | | | +69.07 |
| V_a | | | | | | | | | -17.08 |
| V_d | | | | | | | | | + .09 |
| Curvature..... | | | | | | | | | - .28 |

* Check measurement.

Radial velocity..... +51.8

 θ AQUILÆ 1876.1908. Sept. 8.
G. M. T. 13^h 40^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|--------------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0136 | | | | 1½ | 45.3945 | .3014 | .0627 | 65.45 |
| ½ | 72.9175 | .9105 | .0457 | +66.31 | 1 | 27.5001 | .4706 | .0580 | 50.34 |
| 2 | 72.4645 | | | | 2 | 27.2761 | | | |
| 2 | 54.7428 | | | | 1½ | 11.9869 | .9574 | .1060 | +79.30 |
| 1½ | 54.0359 | .0350 | .0652 | 75.04 | 2 | 11.5444 | | | |
| 2 | 45.2767 | | | | | | | | |
| Weighted mean..... | | | | | | | | | +68.88 |
| V_a | | | | | | | | | -17.08 |
| V_d | | | | | | | | | .00 |
| Curvature..... | | | | | | | | | - .28 |

Radial velocity..... +51.5

 θ AQUILÆ 1878.1908. Sept. 11.
G. M. T. 15^hObserved by J. B. CANNON.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|--------------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0192 | | | | 2 | 45.2692 | | | |
| ½ | 72.8480 | .8396 | .0252 | -36.56 | 1 | 45.2233 | .2277 | .0110 | 11.48 |
| 2 | 72.4503 | | | | 1 | 27.3789 | .3712 | .0414 | 35.93 |
| 2 | 54.7399 | | | | 2 | 27.2541 | | | |
| 2 | 53.9497 | .9515 | .0183 | 21.06 | 1½ | 11.8406 | .8283 | .0231 | +17.30 |
| 2 | 53.1104 | | | | 2 | 11.5249 | | | |
| Weighted mean..... | | | | | | | | | -22.29 |
| V_a | | | | | | | | | -20.21 |
| V_d | | | | | | | | | - .09 |
| Curvature..... | | | | | | | | | - .28 |

Radial velocity..... -47.7

RECORD OF SPECTROGRAMS.
OBSERVING RECORD AND DETAILED MEASURES OF MERCULIN.

P.—Plaskett,
H.—Harper,
C.—Canon,
P.—Parker,
T.—Tribble.

| Star. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure G. M. T. | D. ration. | Hour Angle at end. | | TEMPERATURE CENTIGRADE. | | | | Slit Width. | Seeing. | Observer. | Remarks. |
|-------------|------------------|---------|---------|----------|--------------------------------|------------|-----------------------|-------|----------------------------|------|-----------------|------|-------------|-----------|-----------|----------|
| | | | | | | | h. | m. | Room. | | Prism Box. | | | | | |
| | | | | | | | | | Begin- ning. | End. | Begin- ning. | End. | | | | |
| ell-reclus. | 786 | H. | Secd 27 | May 24 | 18 25 | 20 | h. | m. | 8.5 | 9.5 | 16.4 | 16.4 | 001 | Fair. | P. | |
| " | 800 | " | " | " 31 | 17 38 | 20 | 0 | 40 W. | 12.7 | 12.6 | 18.8 | 18.8 | 001 | Good. | P. | |
| " | 810 | " | " | June 8 | 19 28 | 30 | 2 | 25 W. | 13.0 | 13.0 | 16.9 | 16.8 | 001 | " | P. | |
| " | 816 | " | " | " 10 | 17 47 | 35 | 1 | 50 W. | 13.1 | 12.8 | 17.9 | 17.9 | 001 | " | P. | |
| " | 827 | " | " | " 11 | 15 39 | 26 | 5 | 33 E. | 15.6 | 15.5 | 19.1 | 19.1 | 001 | " | H. | |
| " | 838 | " | " | " 12 | 18 35 | 30 | 2 | 10 W. | 15.4 | 15.2 | 19.0 | 18.9 | 001.2 | Fair. | P. | |
| " | 847 | " | " | " 13 | 18 25 | 16 | 1 | 35 W. | 19.0 | 19.8 | 25.8 | 25.8 | 001.5 | " | H. | |
| " | 851 | " | " | " 14 | 17 43 | 34 | 1 | 30 W. | 20.5 | 19.8 | 23.1 | 23.1 | 001.2 | " | H. | |
| " | 862 | " | " | " 20 | 16 37 | 31 | 1 | 46 W. | 21.5 | 21.0 | 25.4 | 25.4 | 001.2 | " | H. | |
| " | 871 | " | " | " 21 | 18 10 | 35 | 2 | 25 W. | 23.1 | 22.6 | 29.0 | 29.0 | 001 | " | P. | |
| " | 881 | " | " | " 25 | 16 04 | 28 | 3 | 30 W. | 23.8 | 23.8 | 27.3 | 27.3 | 001.2 | Good. | H. | |
| " | 893 | " | " | " 27 | 16 32 | 35 | 1 | 10 W. | 20.9 | 20.0 | 24.5 | 24.5 | 001.2 | Fair. | H. | |
| " | 913 | " | July | 4 | 16 18 | 40 | 1 | 25 W. | 20.0 | 19.5 | 28.6 | 28.4 | 001.2 | Poor. | H. | |
| " | 920 | " | " | 8 | 16 00 | 33 | 1 | 30 W. | 21.2 | 21.2 | 22.4 | 22.4 | 001.2 | Fair. | P. | |
| " | 928 | " | " | " 9 | 15 15 | 38 | 4 | 40 W. | 22.2 | 22.2 | 24.8 | 24.8 | 001.2 | Good. | T. | |
| " | 937 | " | " | " 10 | 14 55 | 30 | 2 | 22 W. | 24.5 | 23.6 | 24.7 | 24.6 | 001.2 | Poor. | P. | |
| " | 952 | " | " | " 18 | 16 10 | 60 | 2 | 22 W. | 22.5 | 22.5 | 28.5 | 28.5 | 001.4 | Fair. | H. | |
| " | 957 | " | " | " 20 | 16 39 | 32 | 2 | 45 W. | 18.6 | 18.8 | 21.5 | 21.5 | 001.2 | Good. | P. | |
| " | 976 | " | " | Aug. 1 | 17 29 | 50 | 4 | 24 W. | 20.0 | 20.0 | 24.8 | 24.8 | 001.2 | Very hazy | T. | |
| " | 979 | " | " | " 3 | 13 28 | 34 | 3 | 30 W. | 20.8 | 20.3 | 24.1 | 24.0 | 001.2 | Poor. | P. | |
| " | 987 | " | " | " 6 | 17 35 | 53 | 4 | 15 W. | 19.4 | 18.0 | 23.3 | 23.3 | 001.3 | Poor. | T. | |
| " | 1018 | " | " | " 22 | 15 49 | 53 | 4 | 15 W. | 18.5 | 18.0 | 24.2 | 24.2 | 001.4 | Fair. | H. | |
| " | 1062 | " | " | Sept. 20 | 14 37 | 45 | 4 | 34 W. | 22.3 | 22.3 | 22.9 | 22.6 | 001.4 | Poor. | H. | |
| | | | | 1908. | | | | | | | | | | | | |
| " | 1301 | " | " | Mar. 9 | 20 50 | 60 | 1 | 31 E. | 12.5 | 13.0 | 1.0 | 1.0 | 001.3 | Good. | H. | |
| " | 1403 | " | " | " 16 | 21 42 | 50 | 1 | 16 E. | 13.0 | 13.5 | 2.3 | 2.3 | 001.4 | Poor. | H. | |
| " | 1483 | " | " | Apr. 13 | 21 35 | 60 | 1 | 36 W. | 0.5 | 1.5 | 8.0 | 8.0 | 001.8 | Poor. | H. | |

| | | | | | | | | | | | | |
|------|--------|----|----|----|--------------|------|------|------|------|-------|--------------|---|
| 1894 | 13 | 20 | 40 | 11 | 40 W. | 3.6 | 2.6 | 7.6 | 4.6 | .0013 | Good | P |
| 1911 | 22 | 20 | 33 | 48 | 1 28 W. | 3.5 | 12.5 | 12.5 | 18.6 | .0017 | " | H |
| 1931 | May | 19 | 29 | 48 | 28 W. | 13.0 | 11.5 | 17.8 | 18.0 | .0017 | " | H |
| 1940 | " | 18 | 18 | 25 | 40 38 W. | 16.6 | 16.5 | 23.4 | 23.4 | .0016 | Fair | P |
| 1945 | " | 20 | 17 | 15 | 13 W. | 18.9 | 16.9 | 21.0 | 21.0 | .0016 | St. dy. hazy | P |
| 1947 | " | 22 | 18 | 28 | 57 58 W. | 20.0 | 20.0 | 25.0 | 25.0 | .0017 | Fair | P |
| 1967 | June | 1 | 19 | 30 | 40 40 | 13.6 | 12.5 | 21.2 | 21.2 | .0015 | " | P |
| 1973 | " | 3 | 17 | 56 | 60 60 | 14.2 | 13.7 | 18.3 | 18.3 | .0015 | " | P |
| 1982 | " | 5 | 18 | 40 | 2 35 W. | 16.6 | 15.5 | 24.5 | 24.5 | .0016 | " | P |
| 1993 | " | 12 | 18 | 33 | 60 60 | 17.0 | 19.7 | 24.9 | 24.9 | .0017 | Good | P |
| 1995 | " | 22 | 17 | 27 | 62 45 | 18.0 | 17.6 | 23.8 | 23.8 | .0015 | " | P |
| 1999 | " | 24 | 16 | 27 | 2 00 W. | 21.5 | 20.5 | 27.5 | 27.6 | .0015 | " | P |
| 1940 | " | 26 | 16 | 46 | 1 43 W. | 20.0 | 17.7 | 30.0 | 30.0 | .0016 | H.C. | P |
| 1948 | " | 27 | 17 | 07 | 55 2 00 W. | 20.5 | 19.8 | 23.8 | 23.7 | .0014 | " | P |
| 1953 | July | 1 | 16 | 18 | 1 30 W. | 23.5 | 21.0 | 25.8 | 26.8 | .0015 | Cloudy | P |
| 1958 | " | 3 | 16 | 18 | 60 1 40 W. | 21.9 | 21.5 | 25.4 | 25.4 | .0016 | " | P |
| 1961 | " | 3 | 19 | 40 | 60 5 05 W. | 20.0 | 19.5 | 25.1 | 25.1 | .0016 | Hazy | P |
| 1966 | " | 6 | 17 | 35 | 60 3 00 W. | 25.8 | 23.6 | 26.4 | 26.4 | .0015 | Good | P |
| 1975 | " | 8 | 15 | 47 | 40 1 15 W. | 19.0 | 18.0 | 21.8 | 21.6 | .0015 | " | C |
| 1976 | " | 8 | 16 | 32 | 45 2 05 W. | 18.0 | 17.5 | 21.6 | 21.6 | .0015 | " | C |
| 1982 | " | 9 | 17 | 12 | 50 2 47 W. | 20.0 | 19.7 | 21.5 | 21.5 | .0015 | " | C |
| 1985 | " | 10 | 14 | 37 | 60 22 W. | 24.5 | 24.0 | 27.4 | 27.4 | .0016 | " | C |
| 1986 | " | 10 | 13 | 34 | 52 1 12 W. | 24.0 | 22.5 | 27.5 | 27.5 | .0016 | " | H |
| 1993 | " | 11 | 16 | 58 | 53 2 45 W. | 19.5 | 26.5 | 30.1 | 29.9 | .0015 | Fair | P |
| 1999 | " | 13 | 16 | 19 | 52 2 15 W. | 19.6 | 19.5 | 23.1 | 23.1 | .0015 | " | P |
| 1970 | " | 14 | 17 | 42 | 48 3 35 W. | 20.5 | 20.0 | 20.6 | 20.6 | .0016 | Good | P |
| 1712 | " | 15 | 17 | 00 | 40 3 35 W. | 17.0 | 16.3 | 22.3 | 22.3 | .0015 | " | C |
| 1713 | " | 15 | 17 | 45 | 40 3 40 W. | 16.3 | 15.0 | 22.3 | 22.0 | .0015 | " | H |
| 1719 | " | 16 | 17 | 25 | 43 3 26 W. | 18.0 | 17.0 | 19.6 | 20.0 | .0015 | " | H |
| 1729 | " | 22 | 17 | 00 | 14.5 3 00 W. | 22.6 | 21.0 | 24.7 | 24.7 | .0015 | Very poor | P |
| 1723 | " | 24 | 14 | 00 | 60 4 0 W. | 24.0 | 23.0 | 26.3 | 26.2 | .0016 | Fair | P |
| 1728 | " | 25 | 17 | 20 | 85 4 30 W. | 20.6 | 20.5 | 24.6 | 24.5 | .0015 | Poor | P |
| 1729 | " | 26 | 17 | 20 | 85 4 30 W. | 23.0 | 22.0 | 23.6 | 23.6 | .0016 | Good | H |
| 1731 | " | 28 | 17 | 12 | 45 4 02 W. | 24.0 | 23.0 | 29.8 | 29.8 | .0016 | " | H |
| 1735 | " | 29 | 14 | 22 | 55 1 50 W. | 27.5 | 27.0 | 30.3 | 30.2 | .0015 | Hazy | P |
| 1738 | " | 29 | 15 | 08 | 30 1 53 W. | 27.0 | 26.6 | 30.2 | 30.2 | .0015 | Fair | P |
| 1743 | " | 29 | 18 | 05 | 60 4 58 W. | 25.6 | 25.0 | 30.1 | 30.0 | .0015 | " | P |
| 1746 | " | 30 | 17 | 06 | 30 4 00 W. | 27.0 | 26.0 | 31.1 | 31.1 | .0015 | " | H |
| 1751 | " | 31 | 15 | 40 | 30 2 40 W. | 21.0 | 20.0 | 26.0 | 26.0 | .0015 | Good | P |
| 1757 | " | 31 | 15 | 40 | 60 6 14 W. | 18.5 | 17.0 | 25.6 | 25.3 | .0013 | " | H |
| 1760 | Aug. 1 | 31 | 16 | 49 | 82 4 15 W. | 20.6 | 20.4 | 23.2 | 23.2 | .0015 | Fair | P |
| 1761 | " | 5 | 14 | 05 | 50 1 30 W. | 22.6 | 22.6 | 27.0 | 27.0 | .0015 | " | P |
| 1764 | " | 7 | 15 | 35 | 80 3 25 W. | 20.2 | 19.1 | 23.6 | 23.6 | .0015 | Very hazy | P |
| 1782 | " | 13 | 16 | 50 | 4 50 W. | 18.6 | 18.1 | 22.8 | 22.6 | .0015 | Fair | P |
| 1793 | " | 15 | 16 | 50 | 48 3 17 W. | 16.5 | 14.5 | 23.8 | 23.6 | .002 | " | H |
| 1818 | III. | 24 | 14 | 03 | 52 2 45 W. | 17.5 | 17.0 | 23.3 | 23.2 | .0015 | Good | H |
| 1838 | II. | 27 | 15 | 50 | 45 4 36 W. | 17.0 | 16.3 | 23.0 | 22.8 | .0015 | " | H |
| 1811 | " | 28 | 14 | 07 | 45 3 00 W. | 18.5 | 17.0 | 23.2 | 23.2 | .0015 | " | C |
| 1853 | " | 28 | 13 | 52 | 46 2 55 W. | 21.0 | 22.0 | 28.0 | 27.8 | .0015 | Fair | H |
| 1866 | Sep. | 31 | 14 | 32 | 56 3 33 W. | 19.3 | 18.8 | 23.5 | 23.4 | .0015 | " | C |

RECORD OF SPECTROGRAMS—Continued.

P.—Plaskett.
H.—Harper.
C.—Cannon.
P.—Parker.
T.—Tribble.

| Star. | No. of Negative. | Camera. | Plat. | Date. | Middle of Exposure G. M. T. | Duration. | Hour Angle at end. | TEMPERATURE CENTIGRADE. | | | | Slit Width. | Seeing. | Observer. | Remarks. | |
|------------|------------------|---------|----------|----------|--------------------------------|-----------|-----------------------|----------------------------|------|-----------------|------|----------------|---------|-----------|----------|--|
| | | | | | | | | Room. | | Prism Box. | | | | | | |
| | | | | | | | | Begin- ning. | End. | Begin- ning. | End. | | | | | |
| e Herulis. | 1903 | HL | Seed 27. | 1908. | h. m. | m. | h. m. | h. m. | 13 5 | 12 5 | 19 0 | 18 8 | .0015 | Bad. | H | |
| | " | " | " | Oct. 1. | 13 12 | 60 | 4 30 W. | 9 2 | 8 0 | 13 2 | 13 1 | .0015 | Clear | P | | |
| | " | " | " | " 2. | 12 23 | 44 | 3 40 W. | 8 0 | 7 3 | 13 1 | 13 0 | .0015 | Good | P | | |
| | " | " | " | " 2. | 13 18 | 44 | 4 30 W. | 9 7 | 8 5 | 14 5 | 14 5 | .0015 | Hazy | P | | |
| | " | " | " | " 5 | 12 45 | 50 | 4 10 W. | 5 9 | 5 5 | 6 6 | 7 2 | .0016 | Good | P | | |
| | " | " | " | Nov. 12. | 14 15 | 60 | 6 25 W. | 3 5 | 3 0 | 8 3 | 7 3 | .0015 | " | H | | |
| | " | " | " | Nov. 13. | 10 33 | 53 | 4 32 W. | 11 0 | 12 0 | 12 0 | 13 0 | .0016 | " | H | | |
| | " | " | " | " 26. | 16 07 | 45 | 4 52 W. | 7 5 | 8 2 | 2 0 | 2 0 | .0016 | Windy | C | | |
| " | 2263 | " | " | 1909. | h. m. | m. | h. m. | h. m. | 19 0 | 18 0 | 5 3 | 5 1 | .0016 | Fair | H | |
| | " | " | " | Feb. 8. | 22 08 | 45 | 2 12 E. | 18 0 | 19 0 | 5 1 | 5 0 | .0016 | " | H | | |
| | " | " | " | " 8. | 23 00 | 56 | 1 15 E. | 6 0 | 7 8 | 6 8 | 6 6 | .0016 | " | C | | |
| | " | " | " | " 22. | 21 34 | 62 | 1 45 E. | 7 8 | 7 5 | 6 6 | 6 6 | .0016 | " | C | | |
| | " | " | " | " 22. | 22 36 | 60 | 1 43 E. | 5 8 | 6 4 | 6 6 | 6 7 | .0016 | " | C | | |
| | " | " | " | Mar. 3. | 21 12 | 75 | 1 25 E. | 6 4 | 6 4 | 6 7 | 6 7 | .0016 | Poor | C | | |
| | " | " | " | " 3. | 22 26 | 68 | 3 10 E. | 2 0 | 1 9 | 3 0 | 2 9 | .002 | Fair | P | | |
| | " | " | " | " 13. | 18 55 | 30 | 3 25 E. | 1 9 | 2 0 | 2 9 | 2 8 | .002 | " | P | | |
| | " | " | " | " 13. | 19 23 | 24 | 3 00 E. | 5 0 | 5 2 | 0 8 | 1 2 | .002 | Good | H | | |
| | " | " | " | " 15. | 19 32 | 27 | 2 29 E. | 5 2 | 5 0 | 1 2 | 1 2 | .002 | " | H | | |
| | " | " | " | " 15. | 20 40 | 27 | 2 13 E. | 1 0 | 0 6 | 9 8 | 9 8 | .002 | " | C | | |
| | " | " | " | " 31. | 31 20 | 50 | 1 00 E. | 0 6 | 0 0 | 9 8 | 9 7 | .002 | " | C | | |
| | " | " | " | " 31. | 30 39 | 32 | 1 25 E. | 0 6 | 0 0 | 9 8 | 9 7 | .002 | " | C | | |

SESSIONAL PAPER No. 25a

1907. May 24.
G. M. T. 18^h 25^m

e HERCULIS 786

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 73-9685 | 4891-134 | | | | |
| 1½ | 73-1420 | 4871-413 | | | | |
| 2 | 72-6821 | 4860-564 | 607 | 627 | 920 | -56-76 |
| 2 | 56-5256 | 4528-760 | | | | |
| 2 | 53-8061 | 4480-945 | 985 | 400 | 415 | -27-76 |

| | |
|--------------------|---------|
| Weighted mean..... | - 56.33 |
|--------------------|---------|

| | |
|-----------------|--------|
| V_g | + 1.45 |
|-----------------|--------|

| | |
|-------------|-----|
| V_d | 104 |
|-------------|-----|

Curvature - 28

Radial velocity, -55.4 ϵ HERCULIS 891

1907. May 31.
G. M. T. 17^h 38^m

Observed by J. S. PLASKETT.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 12 | 73.0174 | ..... | ..... | ..... | 1 | 53.9504 | .9078 | .0620 | 71.36 |
| 12 | 72.8193 | .8105 | .0543 | -78.79 | 2 | 53.1565 | ..... | ..... | ..... |
| 12 | 72.4559 | ..... | ..... | ..... | 2 | 45.2192 | .1557 | .0830 | -86.65 |
| 12 | 54.7825 | ..... | ..... | ..... | 2 | 45.3368 | ..... | ..... | ..... |

| | |
|--------------------|--------|
| Weighted mean..... | -89.45 |
|--------------------|--------|

| | | | |
|-------------|-------|---|----|
| V_{β} | | - | 68 |
|-------------|-------|---|----|

| | | |
|-------------|---|-----|
| V_d | = | .02 |
|-------------|---|-----|

Curvature - 28

Radial velocity..... -81.4

ε HERCULIS 810.

1907. June 8.
G. M. T. 19^h 28^m

Observed by J. S. PLASKETT.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72° 9982 | ..... | ..... | ..... | 3 | 53° 9506 | 8942 | 0756 | - 87° 02 |
| 1 | 72° 8130 | 8281 | 0367 | - 53° 25 | 2 | 53° 1734 | ..... | ..... | ..... |
| 2 | 72° 4367 | ..... | ..... | ..... | 2 | 45° 3626 | ..... | ..... | ..... |
| 2 | 54° 7931 | ..... | ..... | ..... | 1 | 45° 2450 | 1556 | 0831 | - 86° 76 |

| | |
|-------------------------|---------|
| Weighted mean | - 80.21 |
|-------------------------|---------|

| | |
|---------------|---------|
| var mean..... | = 80.21 |
| V_d | = 3.00 |

| | |
|-------------|------|
| V_d | 0.00 |
| V_d | 0.19 |

Curvature..... - 28

Radial velocity... -83.7

9-10 EDWARD VII., A. 1910

ε HERCULIS 816.

1907. June 10.
G. M. T. 17^h 47^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|---------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|---------------|-----------|
| 2 | 73 3707 | 4875 671 | ..... | ..... | ..... | ..... | 1½ | 53 2681 | 4470 617 | ..... | ..... | ..... | ..... |
| 1½ | 72 9235 | 4865 085 | ..... | ..... | ..... | ..... | 2 | 45 2728 | 4341 820 | ..... | ..... | ..... | ..... |
| 1 | 72 7904 | 4861 951 | 807 | 527 | 320 | +19 74 | 2 | 45 2356 | 4341 256 | 594 | 634 | 040 | - 2 76 |
| 2 | 54 3881 | 4489 915 | ..... | ..... | ..... | ..... | 2 | 27 4999 | 4102 238 | 106 | 890 | 216 | +15 60 |
| 1 | 53 9850 | 4482 931 | 150 | 400 | 750 | +50 17 | 2 | 27 3170 | 4100 053 | ..... | ..... | ..... | ..... |

Weighted mean. -16 04
 V_a - 3 37
 V_d - 07
Curvature..... - 28

Radial velocity +12 7

ε HERCULIS 827.

1907. June 11.
G. M. T. 15^h 39^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9503 | ..... | ..... | ..... | 1 | 54 0175 | 0146 | 0448 | -51 56 |
| 1 | 72 8122 | 8724 | 0076 | +11 02 | 3 | 45 3037 | ..... | ..... | ..... |
| 2 | 72 3825 | ..... | ..... | ..... | ½ | 45 2540 | 2237 | 0150 | -15 06 |
| 2 | 54 0317 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean. -21 49
 V_a -3 86
 V_d - 07
Curvature - 28

Radial velocity..... -17 8

ε HERCULIS 838.

1907. June 12.
G. M. T. 18^h 35^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9986 | ..... | ..... | ..... | 2½ | 45 2585 | 1957 | 0130 | 44 89 |
| 1½ | 72 8169 | 8258 | 0390 | -56 59 | 2 | 45 3356 | ..... | ..... | ..... |
| 2 | 72 4380 | ..... | ..... | ..... | ½ | 27 4375 | 3116 | 1010 | -87 67 |
| 2 | 54 0675 | ..... | ..... | ..... | 2 | 27 3726 | ..... | ..... | ..... |
| ½ | 53 9500 | 9113 | 0585 | 67 33 | | | | | |

Weighted mean..... -54 93
 V_a - 4 15
 V_d - 14
Curvature - 28

Radial velocity..... -59 5

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 838.1907, June 12.
G. M. T. 18^h 35^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 72.9698 | | | | 1 | 45.2100 | .1853 | .6534 | 55.74 |
| 1 | 72.7742 | .7756 | .6892 | -56.87 | 2 | 43.5655 | | | |
| 1½ | 72.3915 | | | | 1 | 27.4011 | .3175 | .6651 | 82.54 |
| 2 | 45.2682 | | | | 2 | 27.33.3 | | | |

Weighted mean..... -61.55
 V_a -4.15
 V_d -'.14
 Curvature..... -'.28

Radial velocity..... -66.1

The mean of the two measurements, -61.7 used.

 ϵ HERCULIS 847.1907, June 13.
G. M. T. 18^h 25^mObserved by W. E. HARPER.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7738 | | | | 2 | 45.3226 | | | |
| 2 | 53.9288 | .8948 | .0750 | -86.32 | 2 | 45.1962 | .1472 | .6915 | -95.52 |
| 2 | 53.1442 | | | | | | | | |

Weighted mean..... -90.87
 V_a -4.43
 V_d -'.16
 Curvature..... -'.28

Radial velocity..... 95.7

 ϵ HERCULIS 847.1907, June 13.
G. M. T. 15^h 25^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9662 | | | | 1 | 52.2373 | | | |
| 1½ | 72.7752 | .8186 | .0462 | -67.63 | 2 | 48.7615 | | | |
| 1 | 72.4080 | | | | 1½ | 45.2105 | .2068 | .6319 | -33.30 |
| 1 | 54.0198 | | | | 1 | 45.2774 | | | |
| 1 | 53.8890 | .8960 | .0708 | -81.48 | | | | | |

Weighted mean..... -65.82
 V_a -4.43
 V_d -'.16
 Curvature..... -'.28

Radial velocity..... -70.7

Mean of two measurements, -83.2 used.

9-10 EDWARD VII., A. 1910

ε HERCULIS 851.

1907. June 14.
G. M. T. 17^h 43^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Measured Wave Length. | Normal wave length. | Displacement. | Velocity. | Wt. | Mean of Settings. | Measured Wave Length. | Normal wave length. | Displacement. | Velocity. |
|-----|-------------------|-----------------------|---------------------|---------------|-----------|-----|-------------------|-----------------------|---------------------|---------------|-----------|
| 2 | 73·3997 | 4875·675 | ..... | ..... | ..... | 1½ | 53·9475 | 4482·744 | ·400 | ·344 | +23·74 |
| 1½ | 72·9468 | 4864·956 | ..... | ..... | ..... | 2 | 45·2453 | 4341·337 | ..... | ..... | ..... |
| 1 | 72·8165 | 4861·887 | ·527 | ·300 | +22·21 | 1½ | 45·2036 | 4340·334 | ·634 | ·100 | - 6·96 |
| 1 | 72·3854 | 4851·790 | ..... | ..... | ..... | 1 | 27·4152 | 4101·900 | ·890 | ·010 | + 0·73 |
| 1 | 53·9856 | 4482·656 | ..... | ..... | ..... | 2 | 27·2529 | 4669·650 | ..... | ..... | ..... |

Weighted mean..... + 9·64

 V_a - 4·72 V_d - ·09

Curvature..... - ·28

Radial velocity + 4·5

ε HERCULIS 851.

1907. June 14
G. M. T. 17^h 43^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73·0227 | ..... | ..... | ..... | 1 | 53·1210 | ..... | ..... | ..... |
| 1 | 72·8756 | ·8898 | ·0250 | +36·27 | 1½ | 45·2536 | ·2267 | ·0120 | -12·52 |
| ½ | 72·4630 | ..... | ..... | ..... | 2 | 45·3006 | ..... | ..... | ..... |
| 1 | 54·7568 | ..... | ..... | ..... | 2 | 27·2977 | ..... | ..... | ..... |
| 1 | 54·0085 | ·9691 | ·0293 | +33·72 | 1 | 27·4617 | ·1108 | ·0018 | - 1·56 |

Weighted mean..... -17·76

 V_a - 4·72 V_d - ·09

Curvature..... - ·28

The mean of two measurements, $\pm 7^{\circ} 0$ used.

Radial velocity..... -12·7

ε HERCULIS 862.

1907. June 20.
G. M. T. 16^h 37^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1½ | 72·9908 | ..... | ..... | ..... | 2 | 53·1120 | ..... | ..... | ..... |
| 2 | 72·4301 | ..... | ..... | ..... | 2 | 45·2676 | ..... | ..... | ..... |
| 1 | 72·8461 | ·8644 | ·0004 | - 0·29 | 1 | 45·1917 | ·1977 | ·0410 | -42·79 |
| 2 | 54·7464 | ..... | ..... | ..... | 2 | 27·2746 | ..... | ..... | ..... |
| ½ | 53·9312 | ·9290 | ·0408 | -46·96 | ½ | 27·3742 | ·3462 | ·0764 | -57·70 |

Weighted mean..... - 31·26

 V_a - 6·33 V_d - ·07

Curvature..... - ·28

Radial velocity..... -37·9

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 862.1907, June 20.
G. M. T. 16^h 37^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0166 | ..... | ..... | ..... | 1 | 45.2182 | .1950 | .0437 | 45.62 |
| 1 | 72.8604 | .8527 | .0121 | -17.55 | 2 | 43.5599 | ..... | ..... | ..... |
| 2 | 72.4557 | ..... | ..... | ..... | 1 | 27.4358 | .3833 | .0293 | -25.43 |
| 2 | 45.2969 | ..... | ..... | ..... | 2 | 27.2991 | ..... | ..... | ..... |

Weighted mean..... -27.53
 V_a -6.33
 V_d -.07
 Curvature..... -.28

Radial velocity..... -34.2

Mean of measurements, -34.5 used.

 ϵ HERCULIS 871.1907, June 21.
G. M. T. 18^h 10^mObserved by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 $\frac{1}{2}$ | 72.9582 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 45.1420 | .1655 | .0732 | 76.39 |
| 2 | 72.3957 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.2546 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 72.7847 | .8357 | .0291 | -42.22 | $\frac{1}{2}$ | 27.3658 | .3578 | .0641 | -55.63 |
| 2 | 45.2501 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... -58.78
 V_a -6.49
 V_d -.19
 Curvature..... -.28

Radial velocity.... -65.7

 ϵ HERCULIS 881.1907 June 25.
G. M. T. 16^h 04^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 49.4200 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.3185 | .3189 | .1030 | -89.40 |
| 1 | 45.2146 | .1775 | .0612 | -63.89 | 1 | 27.2462 | ..... | ..... | ..... |
| 2 | 44.2931 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... -72.40
 V_a -7.64
 V_d -.04
 Curvature..... -.28

Radial velocity..... -80.4

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 893.1907, June 27.
G. M. T. 16^h 32^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 $\frac{1}{2}$ | 73.2721 | | | | 1 | 53.9786 | .9741 | .0043 | 4.95 |
| 2 | 72.9900 | | | | 2 | 45.2810 | | | |
| 1 $\frac{1}{2}$ | 72.8555 | 8745 | .0097 | -14.07 | 1 | 45.2918 | .2843 | .0456 | -47.59 |
| 2 | 54.0335 | | | | | | | | |

Weighted mean..... +12.64

 V_a - 8.22 V_d11

Curvature..... .28

Radial velocity..... 4.0

 ϵ HERCULIS 913.1907, July 4.
G. M. T. 16^h 18^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.0216 | | | | 2 | 45.2683 | | | |
| 2 | 53.9485 | .9557 | .0141 | -16.22 | | | | | |

Weighted mean..... -16.22

 V_a - 9.98 V_d14

Curvature..... .28

Radial velocity..... -26.6

 ϵ HERCULIS 920.1907, July 8.
G. M. T. 16^hObserved by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9265 | | | | 2 | 45.2319 | | | |
| 2 | 72.3632 | | | | 1 | 45.1886 | .2403 | .0084 | 8.79 |
| 1 $\frac{1}{2}$ | 72.7804 | 8172 | .0015 | - 2.17 | 2 | 27.2471 | | | |
| 1 $\frac{1}{2}$ | 53.9754 | | | | 1 | 27.4015 | .4763 | .0202 | -17.60 |
| 1 | 53.9156 | .9556 | .0010 | - 1.15 | | | | | |

Weighted mean..... - 6.12

 V_a -10.92 V_d14

Curvature..... .28

Radial velocity..... -17.5

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 928.1907. July 9.
G. M. T. 14^h 32^mObserved by } J. N. TRIBBLE.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 $\frac{1}{2}$ | 54.0232 | ..... | ..... | ..... | 1 | 45.2855 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 54.0319 | 0375 | 0677 | +77.91 | 1 $\frac{1}{2}$ | 30.9135 | ..... | 0388 | 49.90 |
| 2 | 45.2815 | ..... | ..... | ..... | 1 | 29.6773 | 6342 | 0501 | +44.42 |

Weighted mean +53.31

 V_a -11.26 V_d -11

Curvature -28

Radial velocity +41.6

 ϵ HERCULIS 928.*1907. July 9.
G. M. T. 14^h 32^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9585 | ..... | ..... | ..... | 2 | 53.9874 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 72.8250 | 8764 | 0116 | +15.83 | 1 $\frac{1}{2}$ | 53.9415 | 9829 | 0131 | +15.08 |
| 1 | 72.3931 | ..... | ..... | ..... | 2 | 45.2441 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 57.8595 | 8969 | 0700 | [+84.28] | 1 $\frac{1}{2}$ | 45.2136 | 2431 | 0044 | +3.82 |
| 1 | 57.7826 | ..... | ..... | ..... | 2 | 29.6396 | 6406 | 0417 | +37.00 |
| 1 $\frac{1}{2}$ | 57.6674 | 7048 | 1220 | [-144.48] | 2 | 29.5979 | ..... | ..... | ..... |

Weighted mean +20.60

 V_a -11.26 V_d -11

Curvature -28

Radial velocity +9.0

* This result used.

 ϵ HERCULIS 937.1907. July 10.
G. M. T. 14^h 55^mObserved by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 72.9735 | ..... | ..... | ..... | 1 | 45.2284 | 2288 | 0199 | -20.83 |
| 1 | 72.8361 | 8261 | 0054 | +7.84 | 2 | 27.2965 | ..... | ..... | ..... |
| 2 | 45.2832 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.4291 | 4545 | 0420 | -36.60 |

Weighted mean -20.86

 V_a -11.49 V_d -09

Curvature -28

Radial velocity -32.7

9-10 EDWARD VII., A. 1910

ε HERCULIS 937.

1907, July 10.
G. M. T. 14^h 55^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 54.6678 | | | | 2 | 45.2191 | | | |
| 1 | 53.8654 | .9382 | .0316 | -36.37 | 1 | 45.1485 | .2100 | .0287 | -29.96 |
| 1 | 53.0465 | | | | | | | | |

Weighted mean -33.16
 V_d -11.49
 V_d - .09
 Curvature - .28
 Radial velocity -45.6

Mean of measurements, -39.0 used.

ε HERCULIS 952.

1907, July 18.
G. M. T. 16^h 10^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9883 | | | | $\frac{1}{2}$ | 53.9283 | .9333 | .0365 | 42.01 |
| 2 | 72.4271 | | | | 2 | 45.2698 | | | |
| 1 | 72.8008 | .8208 | .0440 | -63.85 | 1 | 45.2169 | .2147 | .0240 | -25.05 |
| 2 | 54.0238 | | | | | | | | |

Weighted mean -43.96
 V_d -13.18
 V_d - .19
 Curvature - .28
 Radial velocity 57.6

ε HERCULIS 957.

1907, July 20.
G. M. T. 16^h 39^mObserved by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9599 | | | | 2 | 45.2827 | | | |
| 2 | 72.3852 | | | | 1 | 45.2473 | .2482 | .0000 | 0.00 |
| 1 | 72.8265 | .8315 | .0128 | +18.34 | 2 | 27.3141 | | | |
| 2 | 54.0154 | | | | $\frac{1}{2}$ | 27.5080 | .5158 | .0193 | +16.82 |
| 1 | 53.9642 | .9642 | .0076 | +8.77 | | | | | |

Weighted mean +10.15
 V_d -13.57
 V_d - .19
 Curvature - .28
 Radial velocity - 3.9

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 976.Observed by J. N. TRIBBLE.
Measured by1907. Aug. 1.
G. M. T. 17^h 20^m

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73° 0008 | | | | 2 | 45° 2806 | | | |
| $\frac{1}{2}$ | 72° 8353 | 8443 | 0205 | -29° 74 | 1 | 45° 2454 | 2384 | 0003 | 0 00 |
| 2 | 54° 0320 | | | | 2 | 27° 2821 | | | |
| 2 | 53° 9627 | 9595 | 0103 | 11° 85 | $\frac{1}{2}$ | 27° 4465 | 4110 | 0109 | -9 46 |

Weighted mean 10° 79
 V_a -15 51
 V_d -27
Curvature -28
Radial velocity -26° 8

 ϵ HERCULIS 979.*Observed by J. S. PLASKETT.
Measured by TRIBBLE & HARPER.1907. Aug. 3.
G. M. T. 13^h 28^m

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72° 9868 | | | | $\frac{1}{2}$ | 27° 4924 | 4509 | 0290 | +25° 17 |
| $\frac{1}{2}$ | 72° 8703 | 8953 | 0305 | +44° 26 | 2 | 54° 7430 | | | |
| 2 | 54° 0237 | | | | $\frac{1}{2}$ | 54° 0280 | 0278 | 0620 | +71 36 |
| 2 | 54° 0309 | 0360 | 0662 | +76° 19 | C'tre { | 53° 9537 | 9535 | 0163 | red. |
| 2 | 54° 7369 | | | | | 53° 8760 | 8758 | 0940 | +18° 76 |
| 2 | 45° 2775 | | | | | | | | -108° 19 |
| 1 | 45° 2820 | 2780 | 0393 | +41° 08 | $\frac{1}{2}$ | | | | violet. |
| 2 | 27° 2883 | | | | 2 | 53° 1113 | | | |

*Plate not used in the results.

 ϵ HERCULIS 987.Observed by J. N. TRIBBLE.
Measured by1907. Aug. 6.
G. M. T. 17^h 35^m

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72° 6897 | | | | 2 | 44° 9542 | | | |
| $\frac{1}{2}$ | 72° 5573 | 7843 | 0122 | +17° 75 | 1 | 44° 9849 | 2833 | 0244 | +25° 63 |

Weighted mean +22° 96
 V_a -16° 16
 V_d -28
Curvature -28

Radial velocity +6 2

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 1018.1907. Aug. 22.
G. M. T. 10^h 49^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.0698 | ..... | ..... | ..... | 2 | 45.2977 | ..... | ..... | ..... |
| 1 | 54.0566 | .0156 | .0453 | +52.71 | $\frac{1}{2}$ | 45.3014 | .2774 | .0387 | +40.39 |

Weighted mean +48.60

 V_a -17.45 V_d 27

Curvature..... - .28

Radial velocity..... +30.6

 ϵ HERCULIS 1062.1907. Sept. 20.
G. M. T. 14^h 37^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.0379 | ..... | ..... | ..... | 2 | 45.2630 | ..... | ..... | ..... |
| 1 | 53.9738 | .0647 | .0031 | - 5.86 | 1 | 45.2412 | .2512 | .0125 | -13.04 |

Weighted mean..... + 3.59

 V_a - 5.90 V_d 28

Curvature..... - .28

Radial velocity..... - 2.9

 ϵ HERCULIS 1391.1908. March 9.
G. M. T. 20^h 50^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7533 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.3570 | .3650 | .0566 | 49.13 |
| 2 | 53.9358 | .9253 | .0445 | -51.22 | 2 | 27.2385 | ..... | ..... | ..... |
| 2 | 53.1215 | ..... | ..... | ..... | $\frac{1}{2}$ | 11.7667 | .7807 | .0617 | -46.21 |
| 2 | 45.2735 | ..... | ..... | ..... | 2 | 11.4840 | ..... | ..... | ..... |
| 1 | 45.2060 | .2061 | .0326 | 34.03 | | | | | |

Weighted mean..... -46.03

 V_a +17.06 V_d 14

Curvature..... - .28

Radial velocity..... -28.6

SESSIONAL PAPER No. 25a

ε HERCULIS 1403.

1908. March 16.
G. M. T. 21^h 42^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-------------|-----|-------------------------|--------------------------------|--------------------------------------|-------------|
| 2 | 54.7088 | ..... | ..... | ..... | 1 | 27.4090 | 3380 | .0746 | [- 64.75]† |
| 1 | 53.8238 | .8561 | 1137 | - 129.87 | 1 | 27.3376 | 2666 | 1460 | - 126.73‡ |
| 2 | 53.0835 | ..... | ..... | ..... | 2 | 27.3180 | ..... | ..... | ..... |
| 3 | 45.2754 | ..... | ..... | ..... | 1½ | 11.8287 | 7037 | 1477 | - 110.63 |
| 2 | 45.1363 | .1345 | 1042 | - 108.78 | 2 | 11.6327 | ..... | ..... | ..... |
| 1 | 27.4961 | 4251 | .0125 | [+ 10.85]° | | | | | |

Weighted mean 4 lines..... - 117.66

 V_a + 16.96 V_d + .05

Curvature..... - 28

Radial velocity..... 100.9

Red. † Centre. ‡ Violet.

ε HERCULIS 1483.

1908. April 13.
G. M. T. 21^h 35^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 55.0591 | .0413 | .0839 | - 97.83 | 1½ | 45.2031 | .1830 | .0557 | - 58.15 |
| 2 | 54.7597 | ..... | ..... | ..... | 2 | 73.0290 | ..... | ..... | ..... |
| 3 | 53.8897 | .8728 | .0970 | - 111.65 | 2 | 66.3185 | .2998 | .1119 | + 145.09 |
| 2 | 53.1281 | ..... | ..... | ..... | 1 | 41.4857 | .4625 | 1653 | + 165.30 |
| 2 | 45.2936 | ..... | ..... | ..... | 2 | 41.3097 | ..... | ..... | ..... |

Weighted mean neg. lines..... - 102.63

 V_a + 12.31 V_d - .09

Curvature..... - 28

Radial velocity..... - 90.7

9-10 EDWARD VII., A. 1910

ε HERCULIS 1494.

1908. April 15.
G. M. T. 20^h 40^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7571 | ..... | ..... | ..... | 1 | 27.5470 | .4416 | .0290 | 25.17 |
| 1 | 54.0087 | .9910 | .0212 | -24.40 | 2 | 27.3328 | ..... | ..... | ..... |
| 2 | 53.1325 | ..... | ..... | ..... | 1½ | 12.0567 | .8947 | .0433 | -32.43 |
| 2 | 45.3117 | ..... | ..... | ..... | 2 | 11.6701 | ..... | ..... | ..... |
| 1½ | 45.2995 | .2614 | .0227 | 23.70 | | | | | |

Weighted mean. - 26.75

V_a - 11.87V_d - .04

Curvature. - .28

Radial velocity ... - 38.3

ε HERCULIS 1511.

1908. April 22.
G. M. T. 20^h 33^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7537 | ..... | ..... | ..... | 1½ | 27.4398 | .3576 | .0550 | 47.74 |
| 1 | 53.9496 | .9343 | .0355 | -40.86 | 2 | 27.3292 | ..... | ..... | ..... |
| 2 | 53.1311 | ..... | ..... | ..... | 1 | 11.9322 | .7951 | .0557 | -41.72 |
| 2 | 45.2841 | ..... | ..... | ..... | 2 | 11.6453 | ..... | ..... | ..... |
| 1½ | 45.2051 | .1947 | .0440 | 45.93 | | | | | |

Weighted mean ... 44.61

V_a - 10.16V_d05

Curvature ... - .23

Radial velocity ... - 34.8

SESSIONAL PAPER No. 25a

ε HERCULIS 151L.*

1908, April 22.
G. M. T. 20^h 53^mObserved by J. S. PLASKITT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7475 | ..... | ..... | ..... | 1 | 27.4466 | .3521 | .0605 | 52.51 |
| $\frac{1}{2}$ | 53.9314 | .9240 | .0498 | -57.31 | 2 | 27.3416 | ..... | ..... | ..... |
| 2 | 53.1213 | ..... | ..... | ..... | $\frac{1}{2}$ | 11.9315 | .7915 | .0600 | -44.94 |
| 2 | 45.3027 | ..... | ..... | ..... | 2 | 11.6479 | ..... | ..... | ..... |
| 1 | 45.2245 | .1965 | .0393 | 41.02 | | | | | |

Weighted mean..... - 48.22

 V_a - 10.16 V_d - .05

Curvature..... - .28

* Check measurement.

Radial velocity..... - 38.4

ε HERCULIS 1531.

1908, May 15.
G. M. T. 19^h 29^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0237 | ..... | ..... | ..... | $\frac{1}{2}$ | 45.1314 | .1565 | .0822 | 85.81 |
| $\frac{1}{2}$ | 72.8254 | .8127 | .0521 | -75.59 | 2 | 43.5083 | ..... | ..... | ..... |
| 1 | 72.4550 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.3377 | .3391 | .0825 | -71.04 |
| 1 | 45.2488 | ..... | ..... | ..... | 2 | 27.2542 | ..... | ..... | ..... |

Weighted mean..... - 77.48

 V_a + 3.87 V_d - .11

Curvature..... - .28

Radial velocity..... - 74.0

ε HERCULIS 1531.*

1908, May 15.
G. M. T. 19^h 29^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 45.2620 | ..... | ..... | ..... | 2 | 15.3652 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 45.1435 | .1651 | .0736 | -76.84 | 1 | 15.3325 | .3730 | .1003 | 77.63 |
| 1 | 27.2702 | .3206 | .0920 | 79.86 | 1 | 11.7025 | .7530 | .0984 | -73.70 |
| 2 | 27.1935 | ..... | ..... | ..... | 2 | 11.4650 | ..... | ..... | ..... |

Weighted mean..... - 77.40

 V_a + 3.87 V_d - .11

Curvature..... - .28

Radial velocity..... - 73.9

* Check measurement.

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 1547.1908, May 22,
G. M. T. 18^h 28^mObserved by } W. F. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7307 | | | | 2 | 45 2609 | | | |
| $\frac{1}{2}$ | 53 9873 | 9479 | 0219 | -25.21 | $\frac{1}{2}$ | 45 1984 | 2051 | 0336 | -35.08 |
| 2 | 53 1021 | | | | | | | | |

Weighted mean - 30.15

 V_d - 1.93 V_d - .04

Curvature - .28

Radial velocity - 28.5

 ϵ HERCULIS 1567.1908, June 1,
G. M. T. 17^h 30^mObserved by T. H. PARKER
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7282 | | | | 2 | 45 2682 | | | |
| $\frac{3}{2}$ | 53 8856 | 8976 | 0722 | -83.10 | $\frac{3}{2}$ | 45 1598 | 1652 | 0735 | -76.73 |
| 2 | 53 1018 | | | | | | | | |

Weighted mean - 81.51

 V_d - 1.17 V_d - .16

Curvature - .28

Radial velocity - 83.1

 ϵ HERCULIS 1573.1908, June 3,
G. M. T. 17^h 56^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72 9922 | | | | 2 | 53 1190 | | | |
| 1 | 72 8323 | 8513 | 0135 | -19.59 | 2 | 45 2871 | | | |
| 2 | 72 4216 | | | | $1\frac{1}{2}$ | 45 2517 | 2382 | 0005 | 0.52 |
| 2 | 54 7443 | | | | 1 | 27 4595 | 4062 | 0064 | -5.55 |
| $\frac{1}{2}$ | 53 9692 | 9645 | 0053 | 6.10 | 2 | 27 2999 | | | |

Weighted mean - 7.23

 V_d - 1.74 V_d - .06

Curvature - .28

Radial velocity - 9.3

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1908, June 4
G. M. T. 17^h 56^m ϵ HERCULIS 1573.*Observed by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0222 | ... | ... | ... | $\frac{1}{2}$ | 45.2750 | 2294 | .0093 | 9.71 |
| $\frac{1}{2}$ | 72.8697 | 8570 | .0078 | -11.32 | $\frac{1}{2}$ | 27.4850 | 4000 | .0126 | -10.94 |
| 2 | 72.4536 | ... | ... | ... | 2 | 27.3321 | ... | ... | ... |
| 2 | 45.3195 | ... | ... | ... | | | | | |

Weighted mean. - 10.66
 V_a - 1.74
 V_d - .06
 Curvature28

* Check measurement.

Radial velocity. - 12.7

1908, June 5.
G. M. T. 18^h 40^m ϵ HERCULIS 1582.Observed by } T. H. PARKER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0057 | ... | ... | ... | 2 | 45.2847 | ... | ... | ... |
| $\frac{1}{2}$ | 72.8289 | .8328 | .0320 | 46.43 | 1 | 45.1877 | .1766 | .0621 | 64.83 |
| 1 | 72.4415 | ... | ... | ... | 2 | 43.5492 | ... | ... | ... |
| 1 | 54.7435 | ... | ... | ... | 1 | 27.3405 | .3509 | .0617 | -53.55 |
| 2 | 53.9113 | .9085 | .0613 | 70.55 | 2 | 27.2362 | ... | ... | ... |
| 1 | 53.1160 | ... | ... | ... | | | | | |

Weighted mean. - 62.82
 V_a - 2.34
 V_d - .13
 Curvature28

Radial velocity. 65.6

1908, June 12.
G. M. T. 18^h 35^m ϵ HERCULIS 1603.Observed by } T. H. PARKER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0039 | ... | ... | ... | $\frac{1}{2}$ | 27.3556 | .3660 | .0466 | 40.44 |
| $\frac{1}{2}$ | 72.8098 | .8174 | .0474 | -68.77 | 2 | 27.2362 | ... | ... | ... |
| 2 | 72.4334 | ... | ... | ... | 2 | 54.7252 | ... | ... | ... |
| 2 | 45.2849 | ... | ... | ... | 1 | 53.9368 | .9481 | .0217 | -24.97 |
| 1 | 45.1905 | .1792 | .0595 | 62.11 | 1 | 53.0175 | ... | ... | ... |
| 3 | 43.3509 | ... | ... | ... | | | | | |

Weighted mean. - 47.23
 V_a - 4.39
 V_d - .14
 Curvature28

Radial velocity. - 52.0

SESSIONAL PAPER No. 25a

ε HERCULIS 1633.*

1908, June 12.
G. M. T. 18^h 35^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7390 | | | | 1 | 45.1900 | .1834 | .0553 | -57.73 |
| 1 ¹ | 53.9468 | .9615 | .0183 | -21.06 | 2 | 45.2802 | | | |
| 1 | 53.1052 | | | | | | | | |

Weighted mean -35.73
 V_a 4.39
 V_d 14
 Curvature 28

Radial velocity 40.5

* Check measurement.

ε HERCULIS 1625.

1908, June 22.
G. M. T. 17^h 27^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 1 ¹ | 54.7181 | | | | 2 | 27.4445 | .4251 | .0125 | +10.85 |
| 1 | 53.9437 | .9684 | .0014 | -1.91 | 2 | 27.2660 | | | |
| 1 | 53.0867 | | | | 1 ¹ | 11.8797 | .8502 | .0012 | -0.90 |
| 1 | 45.2605 | | | | 2 | 11.5367 | | | |
| 1 | 45.2005 | .2137 | .0250 | -26.10 | | | | | |

Weighted mean -6.24
 V_a 7.15
 V_d 11
 Curvature 28

Radial velocity -13.8

ε HERCULIS 1630.

1908, June 24.
G. M. T. 16^h 27^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0647 | | | | 2 | 45.3237 | | | |
| 1 | 72.9033 | .8481 | .0167 | -24.23 | 2 | 45.2375 | .2074 | .0313 | 32.68 |
| 2 | 72.5011 | | | | 1 ¹ | 27.4458 | .3860 | .0266 | 23.00 |
| 2 | 54.7925 | | | | 2 | 27.3065 | | | |
| 1 ¹ | 53.1978 | .9484 | .0214 | 24.63 | 2 | 11.8987 | .8362 | .0152 | -11.38 |
| 2 | 53.1602 | | | | 2 | 11.5698 | | | |

Weighted mean -23.00
 V_a 7.68
 V_d 04
 Curvature 28

Radial velocity -31.0

9-10 EDWARD VII., A. 1910

1908. June 26.
G. M. T. 16^h 46^m

ε HERCULIS 1649.

Observed by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|--|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7353 | | | | 2 | 53.1042 | | | |
| 1 | 53.9739 | 9826 | 0128 | +14.73 | | | | | |
| | | | | | V_s + 14.73 V_d - 8.21 V_d - .09 Curvature..... - .28 | | | | |
| | | | | | Radial velocity..... + 6.1 | | | | |

1908. June 27.
G. M. T. 17^h 07^m

ε HERCULIS 1648.

Observed by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|--|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.6613 | | | | 2 | 27.3914 | .4389 | .0266 | 22.06 |
| 1½ | 53.9578 | 6373 | 0675 | -77.80 | 3 | 27.2975 | | | |
| 2 | 53.0325 | | | | 1 | 11.8777 | .9092 | .0578 | +43.29 |
| 2 | 45.2056 | | | | 3 | 11.4693 | | | |
| 1½ | 45.1725 | 2405 | 0918 | 1.88 | | | | | |
| | | | | | Weighted mean..... + 34.49 V_s - 8.47 V_d - .11 Curvature - .28 | | | | |
| | | | | | Radial velocity..... + 25.6 | | | | |

1908. June 27.
G. M. T. 17^h 07^m

ε HERCULIS 1648.*

Observed by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|--|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0323 | | | | 2 | 45.3181 | | | |
| 1 | 72.9046 | .8746 | .0098 | +14.22 | 1½ | 45.2971 | .2531 | .0144 | 15.06 |
| 2 | 72.4869 | | | | 1½ | 27.5276 | .4536 | .0410 | 35.59 |
| 2 | 54.7837 | | | | 3 | 27.3309 | | | |
| 1½ | 54.0660 | .0260 | 0562 | 64.69 | 1½ | 12.0159 | .9229 | .0715 | +53.63 |
| 2 | 53.1513 | | | | 3 | 11.5935 | | | |
| | | | | | Weighted mean..... + 42.15 V_s - 8.47 V_d - .11 Curvature - .29 | | | | |
| | | | | | Radial velocity..... + 29.4 | | | | |

* Check measurement.

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 1648.*1908. June 27.
G. M. T. 17^h 07^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7470 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.4466 | .4322 | .0196 | 17.01 |
| 1 | 54.0110 | .0063 | .0365 | +42.01 | 2 | 27.2610 | ..... | ..... | ..... |
| 2 | 53.1164 | ..... | ..... | ..... | 1 | 11.9287 | .9637 | .0523 | +39.17 |
| 2 | 45.2902 | ..... | ..... | ..... | 2 | 11.5322 | ..... | ..... | ..... |
| $1\frac{1}{2}$ | 45.2737 | .2571 | .0184 | 19.21 | | | | | |

Weighted mean +29.62

 V_a - 8.47 V_d - 11

Curvature - 28

Radial velocity +20.8

* Check measurement.

 ϵ HERCULIS 1653.1908. July 1.
G. M. T. 16^h 15^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7746 | ..... | ..... | ..... | 1 | 27.5156 | .4756 | .0630 | 54.68 |
| 2 | 54.0547 | .0247 | .0549 | +63.19 | 3 | 27.2893 | ..... | ..... | ..... |
| 2 | 53.1395 | ..... | ..... | ..... | $1\frac{1}{2}$ | 11.9291 | .8371 | .0337 | +26.76 |
| 2 | 45.3043 | ..... | ..... | ..... | 3 | 11.5478 | ..... | ..... | ..... |
| 1 | 45.2795 | .2490 | .0103 | 10.75 | | | | | |

Weighted mean +42.17

 V_a - 9.48 V_d - 11

Curvature - 28

Radial velocity +33.3

 ϵ HERCULIS 1653.*1908. July 1.
G. M. T. 16^h 15^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7392 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.4403 | .4400 | .0274 | 23.78 |
| 1 | 53.9887 | .9943 | .0245 | +28.20 | 2 | 27.2470 | ..... | ..... | ..... |
| 1 | 53.1035 | ..... | ..... | ..... | 1 | 11.8804 | .8856 | .0342 | +25.61 |
| 2 | 45.2625 | ..... | ..... | ..... | 2 | 11.5020 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 45.2276 | .2387 | .0000 | .00 | | | | | |

Weighted mean +21.90

 V_a - 9.48 V_d - .06

Curvature - 28

Radial velocity +12.1

* Check measurement.

9-10 EDWARD VII., A. 1910

ε HERCULIS 1633.*

1908, July 1
G. M. T. 16^h 15^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 8447 | ..... | ..... | ..... | 3 | 45 3489 | 2537 | 0150 | 15 66 |
| 1 | 53 0662 | 9977 | 0279 | 32 11 | 1 | 11 9804 | 8880 | 0366 | - 27 41 |
| 2 | 53 2062 | ..... | ..... | ..... | 2 | 11 6036 | ..... | ..... | ..... |
| 2 | 45 3688 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean - 26 94

 V_{α} 9 48 V_{δ} 11

Curvature - 28

Radial velocity . . . - 17 1

* Check measurement.

ε HERCULIS 1661.

1908, July 3.
G. M. T. 19^h 40^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7681 | ..... | ..... | ..... | 2 | 45 2998 | ..... | ..... | ..... |
| 2 | 53 9294 | 9004 | 0694 | 79 88 | 1 | 45 2548 | 2268 | 0119 | - 13 61 |
| 2 | 53 1436 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean 49 53

 V_{α} - 9 97 V_{δ} 26

Curvature - 28

Radial velocity . . . - 60 0

ε HERCULIS 1661.*

1908, July 3.
G. M. T. 19^h 40^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7214 | ..... | ..... | ..... | 2 | 45 2530 | ..... | ..... | ..... |
| 2 | 53 8761 | 8968 | 0730 | - 84 02 | 3 | 45 1670 | 1877 | 0510 | - 53 24 |
| 2 | 53 0911 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean - 75 62

 V_{α} - 9 97 V_{δ} - 26

Curvature - 28

Radial velocity . . . - 86 1

* Check measurement.

SESSIONAL PAPER No. 25a

ε HERCULIS 1666.

1908. July 6.
G. M. T. 17^h 35^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7101 | ..... | ..... | ..... | 1½ | 27 3494 | 3934 | 0192 | 16 66 |
| 1 | 53 8800 | 0180 | 0518 | - 59 62 | 2 | 27 1962 | ..... | ..... | ..... |
| 2 | 53 0710 | ..... | ..... | ..... | 1 | 11 7754 | 8284 | 0230 | - 17 23 |
| 2 | 45 2333 | ..... | ..... | ..... | 2 | 11 4534 | ..... | ..... | ..... |
| 1½ | 45 1985 | 2375 | 0012 | 1 25 | | | | | |

Weighted mean - 20 74
 V_a - 10 70
 V_d - 06
Curvature - 28
Radial velocity - 31 7

ε HERCULIS 1666.*

1908. July 6.
G. M. T. 17^h 35^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57 8433 | ..... | ..... | ..... | 1½ | 45 2230 | 2223 | 0164 | - 17 20 |
| ½ | 57 8432 | 8293 | 0025 | + 3 01 | ½ | 27 3862 | 3874 | 0252 | - 21 87 |
| 2 | 54 7567 | ..... | ..... | ..... | 2 | 27 2454 | ..... | ..... | ..... |
| 2 | 53 9847 | 9752 | 0054 | + 6 21 | ½ | 11 8301 | 8383 | 0131 | - 9 81 |
| 1 | 53 1164 | ..... | ..... | ..... | 2 | 11 5190 | ..... | ..... | ..... |
| 2 | 45 2745 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean - 5 54
 V_a 10 70
 V_d 06
Curvature - 28
Radial velocity. - 16 6

* Check measurement.

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 1673.1908, July 8.
G. M. T. 15^h 47^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0235 | | | | 3 | 45.2741 | | | |
| 1 | 72.8670 | .8534 | .0114 | -16.54 | 1½ | 45.2271 | .2267 | .0120 | -12.53 |
| 2 | 72.4584 | | | | 1 | 27.4307 | .4076 | .0050 | -4.34 |
| 2 | 54.7415 | | | | 2 | 27.2697 | | | |
| 1½ | 53.9786 | .9803 | .0105 | +12.08 | 1 | 11.8571 | .8288 | .0226 | -16.93 |
| 1½ | 53.1090 | | | | 2 | 11.5355 | | | |

Weighted mean. - 6.41
 V_a - 11.15
 V_d - .07
Curvature. - .28

Radial velocity - 17.9

 ϵ HERCULIS 1673.*1908, July 8.
G. M. T. 15^h 47^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1½ | 57.7785 | .8317 | .0049 | +6.02 | 1½ | 45.1881 | .2350 | .0037 | -3.86 |
| 2 | 57.7762 | | | | 2 | 30.8478 | | | |
| 2 | 54.6950 | | | | 1 | 27.3860 | .4972 | .0054 | -4.69 |
| 2 | 53.9312 | .9798 | .0100 | +11.51 | 2 | 27.2254 | | | |
| 2 | 53.0617 | | | | 1 | 11.8146 | .8303 | .0211 | -15.80 |
| 2 | 45.2267 | | | | 2 | 11.4915 | | | |

Weighted mean. 0.04
 V_a - 11.15
 V_d - .07
Curvature. - .28

Radial velocity - 11.5

* Check measurement.

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 1676.1908, July 8,
G. M. T. 16^h 32^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.8885 | ..... | ..... | ..... | 1 | 27.5711 | .4031 | .0095 | 8.25 |
| 1 $\frac{1}{2}$ | 54.0948 | .9498 | .0200 | -23.02 | 2 | 27.4152 | ..... | ..... | ..... |
| 2 | 53.2536 | ..... | ..... | ..... | 1 | 12.0378 | .8489 | .0025 | -1.87 |
| 2 | 45.4243 | ..... | ..... | ..... | 2 $\frac{1}{2}$ | 11.6959 | ..... | ..... | ..... |
| 1 | 45.3866 | .2356 | .0031 | 3.24 | | | | | |

Weighted mean - 10.64
 V_a - 11.15
 V_d - .14
Curvature28

Radial velocity - 22.2

 ϵ HERCULIS 1682.1908, July 9,
G. M. T. 17^h 12^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0156 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 45.2675 | .2565 | .0178 | +18.58 |
| 1 $\frac{1}{2}$ | 72.8768 | .8714 | .0066 | +9.57 | 2 | 41.2977 | ..... | ..... | ..... |
| 2 | 72.4490 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.4402 | .4102 | .0024 | -2.08 |
| 2 | 54.7490 | ..... | ..... | ..... | 2 | 27.2766 | ..... | ..... | ..... |
| 3 | 54.0263 | .0207 | .0009 | +70.09 | 1 $\frac{1}{2}$ | 11.9452 | .9044 | .0530 | +39.70 |
| 2 | 53.1160 | ..... | ..... | ..... | 2 | 11.5482 | ..... | ..... | ..... |
| 2 | 45.2846 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean + 42.97
 V_a - 11.36
 V_d - .15
Curvature28

Radial velocity + 31.2

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 1685.1908. July 10.
G. M. T. 14^h 37^mObserved by J. B. CANNON.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54 7810 | | | | 1½ | 27 4458 | 3880 | 0246 | 21 35 |
| 2 | 53 9982 | 9002 | 0096 | - 11 49 | 2 | 27 3042 | | | |
| 2 | 53 1500 | | | | 1½ | 11 8880 | 8260 | 0254 | 19 02 |
| 2 | 15 3197 | | | | 2 | 11 5696 | | | |
| 1 | 45 2720 | 2260 | 0127 | 13 26 | | | | | |

Weighted mean - 16 13

 V_a 11 58 V_d 00

Curvature 28

Radial velocity - 27 9

 ϵ HERCULIS 1686.1908. July 10.
G. M. T. 15^h 34^mObserved by J. B. CANNON.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54 7365 | | | | ½ | 27 4528 | | | |
| 1½ | 53 9496 | 9535 | 0163 | - 18 76 | 2 | 27 2597 | | | |
| 2 | 53 1102 | | | | 1½ | 11 8304 | 8090 | 0415 | 31 07 |
| 2 | 45 2762 | | | | 2 | 11 5280 | | | |
| 1 | 45 2158 | 2146 | 0230 | 24 01 | | | | | |

Weighted mean - 24 56

 V_a - 11 58 V_d 06

Curvature 28

Radial velocity - 36 1

 ϵ HERCULIS 1693.1908. July 11.
G. M. T. 16^h 58^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73 0160 | | | | 1½ | 45 1437 | 1197 | 1198 | 125 07 |
| 1 | 72 7961 | 7998 | 0650 | - 94 52 | 1 | 27 2885 | 2685 | 1440 | 124 99 |
| 1 | 54 7200 | | | | 2 | 27 2267 | | | |
| 2 | 53 8695 | 8415 | 1283 | 147 67 | 1 | 11 7051 | 6841 | 1673 | - 115 31 |
| 2 | 53 0811 | | | | 2 | 11 4860 | | | |
| 2 | 45 2396 | | | | | | | | |

Weighted mean - 125 81

 V_a - 11 83 V_d 14

Curvature 28

Radial velocity - 138 1

SESSIONAL PAPER No. 25a

1908, July 11,
G. M. T. 16^h 58^m

ε HERCULIS 1693.*

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 54.6857 | | | | 1½ | 27.2729 | 3166 | 6960 | 83.33 |
| 2 | 53.8389 | 8908 | 0790 | -90.93 | 2 | 27.2031 | | | |
| 1 | 53.0466 | | | | 1 | 11.6737 | 7328 | 1186 | 88.83 |
| 2 | 45.2135 | | | | 2 | 11.4481 | | | |
| 1 | 45.1326 | 1927 | 0460 | 48.02 | | | | | |

Weighted mean 80.67
 V_a 11.83
 V_d 14
 Curvature 28

* Check measurement.

Radial velocity..... -92.9

ε HERCULIS 1699.

1908, July 13,
G. M. T. 16^h 19^m

Observed by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 72.9161 | | | | ½ | 27.3386 | 3706 | 0513 | +44.53 |
| 2 | 72.7681 | 8611 | 0037 | -5.37 | 2 | 27.2138 | | | |
| 2 | 72.3520 | | | | 1½ | 11.8957 | 9057 | 0543 | +40.67 |
| 2 | 45.2128 | | | | 2 | 11.4945 | | | |
| 1 | 45.1745 | 2353 | 0034 | -3.55 | | | | | |

Weighted mean +22.90
 V_a -12.28
 V_d 14
 Curvature 28

Radial velocity..... 9.3

ε HERCULIS 1699.*

1908, July 13
G. M. T. 16^h 19^m

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 72.8786 | | | | 1 | 52.9080 | | | |
| 2 | 72.7355 | 8648 | 0000 | 0.00 | 2 | 45.1721 | | | |
| 2 | 72.3211 | | | | 1 | 45.1655 | 2670 | 0283 | +29.54 |
| 2 | 54.6267 | | | | 1½ | 11.8675 | 9317 | 0803 | +60.14 |
| 1 | 53.8710 | 9856 | 0158 | -18.18 | 2 | 11.4430 | | | |

Weighted mean +34.48
 V_a 12.28
 V_d 14
 Curvature 28

* Check measurement.

Radial velocity..... -21.8

9-10 EDWARD VII., A. 1910

ε HERCULIS 1707.

1908. July 14.
G. M. T. 17^h 42^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 72.9823 | | | | 2 | 45.2751 | | | |
| 1 | 72.8174 | .8454 | .0194 | -28.15 | 2 | 45.2115 | .2100 | .0287 | 29.96 |
| 1 | 72.4157 | | | | 2 | 27.4009 | .3709 | .0417 | 36.20 |
| 2 | 54.7221 | | | | 2 | 27.2759 | | | |
| $\frac{1}{2}$ | 53.9413 | .9573 | .0125 | 14.39 | 2 | 11.8686 | .8106 | .0408 | 30.56 |
| 2 | 53.0976 | | | | 2 | 11.5667 | | | |

Weighted mean..... -30.50
 V_d -12.58
 V_d -19
Curvature -28
Radial velocity -43.6

ε HERCULIS 1712.

1908. July 15.
G. M. T. 17^hObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7925 | | | | 1 | 27.4363 | .3593 | .0533 | 46.26 |
| $\frac{1}{2}$ | 53.9323 | .8803 | .0795 | -91.50 | 2 | 27.3102 | | | |
| 2 | 53.1660 | | | | 1 | 11.7814 | .7214 | .1300 | -97.37 |
| 2 | 45.3233 | | | | 2 | 11.5975 | | | |
| $1\frac{1}{2}$ | 45.2363 | .1863 | .0524 | 54.71 | | | | | |

Weighted mean..... -67.88
 V_d -12.81
 V_d -14
Curvature..... -28
Radial velocity..... -81.1

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 1713.1908. July 15.
G. M. T. 17^h 45^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 72.9943 | ..... | ..... | ..... | 2 | 45.2760 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8335 | .8495 | .0153 | - 22.20 | 1 $\frac{1}{2}$ | 45.1889 | .1924 | .0463 | 48.34 |
| 1 | 72.4275 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.3745 | .3583 | .0543 | 47.13 |
| 2 | 54.7248 | ..... | ..... | ..... | 2 | 27.2630 | ..... | ..... | ..... |
| 1 | 53.8913 | .9083 | .0615 | 70.79 | 1 $\frac{1}{2}$ | 11.8010 | .7715 | .0799 | - 59.92 |
| 2 | 53.1022 | ..... | ..... | ..... | 2 | 11.5368 | ..... | ..... | ..... |

Weighted mean - 52.49
 V_a - 12.80
 V_d - 19
Curvature - .28

Radial velocity, - 65.8

 ϵ HERCULIS 1719.1908. July 16.
G. M. T. 17^h 25^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7686 | ..... | ..... | ..... | 1 | 27.4669 | .4142 | .0077 | - 6.68 |
| 2 | 53.9945 | .9675 | .0023 | - 2.65 | 2 | 27.2995 | ..... | ..... | ..... |
| 2 | 53.1389 | ..... | ..... | ..... | 2 | 11.9217 | .8562 | .0048 | + 3.59 |
| 2 | 45.3019 | ..... | ..... | ..... | 2 | 11.5731 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 45.2698 | .2368 | .0019 | - 1.98 | | | | | |

Weighted mean - 0.27
 V_a - 13.03
 V_d - 19
Curvature - .28

Radial velocity .. . - 13.8

9-10 EDWARD VII., A. 1910

HERCULIS 1720.

1908. July 22.
G. M. T. 17^hObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 57.8345 | | | | 1 | 45.2245 | .2114 | .0173 | -18.06 |
| 1 | 57.8370 | 8333 | .0065 | + 7.83 | 1½ | 24.1614 | | .0076 | - 6.46 |
| 1 | 54.7533 | | | | 2 | 24.1536 | | | |
| 1½ | 53.9636 | 9510 | .0188 | -21.64 | 1 | 11.8589 | .8290 | .0224 | -22.57 |
| 1 | 53.1255 | | | | 2 | 11.5373 | | | |
| 2 | 45.2867 | | | | | | | | |

Weighted mean..... - 9.26
 V_a - 14.00
 V_d - .19
Curvature..... - .28
Radial velocity ... - 23.7

HERCULIS 1723.

1908. July 24.
G. M. T. 14^hObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9270 | | | | 2 | 53.0155 | | | |
| ½ | 72.7558 | 8416 | .0232 | -33.66 | 2 | 45.1800 | | | |
| 1 | 72.3561 | | | | 1½ | 45.1312 | .2248 | .0139 | -14.51 |
| 2 | 59.7270 | | | | 2 | 37.8697 | | | |
| 1 | 58.9550 | 0377 | .0030 | - 3.66 | 1½ | 37.6784 | .7674 | .0127 | +12.24 |
| 1 | 57.7351 | .8188 | .0080 | - 9.63 | 1 | 27.3058 | .3850 | .0276 | 23.96 |
| 2 | 57.5079 | | | | 2 | 27.1684 | | | |
| 2 | 54.6556 | | | | 1 | 11.7612 | .8374 | .0140 | 10.49 |
| 1½ | 53.8752 | .9665 | .0033 | - 3.80 | 2 | 11.4310 | | | |

Weighted mean..... - 8.20
 V_a - 14.35
 V_d - .00
Curvature..... - .28
Radial velocity ... - 23.8

SESSIONAL PAPER No. 25a

ε HERCULIS 1728.

1908. July 25.
G. M. T. 17^h 20^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.8772 | | | | 1½ | 45.3992 | .2740 | .0353 | +36.85 |
| 2 | 54.1331 | .0021 | .0323 | +37.18 | 1 | 24.5975 | .4648 | .0522 | +45.31 |
| 2 | 53.2387 | | | | 2 | 24.3793 | | | |
| 2 | 45.3988 | | | | | | | | |

Weighted mean..... + 38.89

 V_a - 14.53 V_d - .22

Curvature..... - .28

Radial velocity..... + 23.9

ε HERCULIS 1729

1908. July 25.
G. M. T. 16^h 58^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0485 | | | | 2 | 53.1465 | | | |
| 1 | 72.8867 | .8482 | .0166 | -24.08 | 2 | 45.3692 | | | |
| 2 | 72.4827 | | | | 1½ | 45.2855 | .2500 | .0113 | +11.80 |
| 1 | 57.8605 | .8279 | .0011 | +1.32 | 1 | 27.4567 | .4100 | .0026 | -2.26 |
| 2 | 57.8620 | | | | 2 | 27.2950 | | | |
| 2 | 54.7767 | | | | 1½ | 11.8964 | .8496 | .0018 | -1.35 |
| 1 | 53.9981 | .9635 | .0063 | -7.25 | 2 | 11.5540 | | | |

Weighted mean..... - 2.37

 V_a - 14.71 V_d - .20

Curvature..... - .28

Radial velocity..... - 17.6

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 1734.1908, July 28.
G. M. T. 17^h 12^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.4230 | | | | 1 | 45.1967 | .2434 | .0047 | + 4.91 |
| 2 | 59.7721 | | | | $\frac{1}{2}$ | 27.3527 | .3951 | .0175 | - 15.19 |
| 2 | 54.7033 | | | | 2 | 27.2043 | | | |
| 1 | 53.9145 | .9547 | .0151 | - 17.38 | 1 | 11.7436 | .8210 | .0304 | - 22.77 |
| 2 | 53.0702 | | | | 2 | 11.4292 | | | |
| 2 | 45.2269 | | | | | | | | |

Weighted mean..... - 12.24
 V_a - 15.07
 V_d - .22
Curvature..... - .28
Radial velocity..... - 27.8

 ϵ HERCULIS 1737.1908, July 29.
G. M. T. 14^h 22^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9830 | | | | 1 | 29.8960 | .9563 | .0333 | + 32.10 |
| 1 | 72.8682 | .8968 | .0320 | + 46.45 | 2 | 29.8627 | | | |
| 1 | 72.4145 | | | | $\frac{1}{2}$ | 27.3845 | .4478 | .0352 | + 30.55 |
| 2 | 54.6912 | | | | 2 | 27.1833 | | | |
| 1 | 53.9795 | .0321 | .0023 | + 71.71 | $1\frac{1}{2}$ | 11.8437 | .9232 | .0718 | + 53.78 |
| 2 | 54.0574 | | | | 1 | 11.6321 | | | |
| 2 | 45.2190 | | | | 2 | 11.4277 | | | |
| 1 | 45.2345 | .2891 | .0504 | + 52.61 | | | | | |

Weighted mean..... + 49.80
 V_a - 15.17
 V_d - .06
Curvature..... - .28
Radial velocity..... + 34.3

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 1738.1908. July 29.
G. M. T. 15^h 08^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7011 | | | | 1 | 45.2290 | .2753 | .0366 | +38.21 |
| 1 | 53.9824 | .0240 | .0542 | +62.38 | 2 | 29.8783 | | | |
| 2 | 53.0696 | | | | 1 | 11.8693 | .9186 | .0672 | +50.35 |
| 2 | 45.2273 | | | | 2 | 11.4489 | | | |

Weighted mean +50.31
 V_a -15.17
 V_d - .11
Curvature - .28
Radial velocity +34.7

 ϵ HERCULIS 1743.1908. July 29.
G. M. T. 18^h 05^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0345 | | | | 2 | 54.0317 | .0317 | .0619 | -71.25 |
| $\frac{1}{2}$ | 72.8884 | .8670 | .0022 | +3.19 | 2 | 53.1037 | | | |
| 2 | 72.4567 | | | | 2 | 45.2694 | | | |
| 2 | 54.7482 | | | | 1 | 45.2692 | .2734 | .0347 | +36.23 |
| 3 | 54.0298 | | | | | | | | |

Weighted mean +55.91
 V_a -15.17
 V_d - .25
Curvature - .28
Radial velocity +40.2

 ϵ HERCULIS 1746.1908. July 30.
G. M. T. 17^h 06^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7460 | | | | 2 | 45.2629 | | | |
| 2 | 53.9640 | .9628 | .0070 | -8.06 | $\frac{1}{2}$ | 45.2283 | .2390 | .0003 | +0.31 |
| 2 | 53.1102 | | | | | | | | |

Weighted mean -6.47
 V_a -15.27
 V_d - .24
Curvature - .28
Radial velocity -22.3

9-10 EDWARD VII. A. 1910

 ϵ HERCULIS 1751.1908. July 31.
G. M. T. 15^h 40^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 57.8225 | | | | 2 | 53.1145 | | | |
| $\frac{1}{2}$ | 57.7790 | .7859 | .0410 | -49.36 | 2 | 45.2711 | | | |
| 2 | 54.7461 | | | | $\frac{1}{2}$ | 45.1693 | .1717 | .0670 | 69.95 |
| $1\frac{1}{2}$ | 53.9111 | .9078 | .0620 | -71.36 | | | | | |

Weighted mean 66.38
 V_a 15.65
 V_d 15
Curvature28
Radial velocity 82.5

 ϵ HERCULIS 1757.1908. July 31.
G. M. T. 19^h 05^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0630 | | | | 2 | 53.1403 | | | |
| 1 | 72.8552 | .8035 | .0613 | -88.95 | 2 | 45.2950 | | | |
| 2 | 72.4921 | | | | 2 | 45.1940 | .1726 | .0661 | 69.00 |
| 2 | 54.7682 | | | | $\frac{1}{2}$ | 27.3792 | .3631 | .0495 | -42.97 |
| $1\frac{1}{2}$ | 53.9147 | .8874 | .0824 | -94.84 | 1 | 27.2627 | | | |

Weighted mean 78.14
 V_a 15.65
 V_d 28
Curvature28
Radial velocity 94.3

 ϵ HERCULIS 1760.1908. Aug. 1.
G. M. T. 16^h 43^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7274 | | | | 2 | 45.2642 | | | |
| $1\frac{1}{2}$ | 53.9500 | .9643 | .0655 | -6.35 | 1 | 45.2251 | .2345 | .0043 | -4.49 |
| 2 | 53.0979 | | | | | | | | |

Weighted mean 5.61
 V_a 16.03
 V_d 22
Curvature28
Radial velocity 22.1

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 1761.1908, Aug. 5.
G. M. T. 14^h 05^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0351 | | | | 2 | 53.1047 | | | |
| 1 | 72.8896 | 8680 | 0032 | + 4.64 | 2 | 45.2597 | | | |
| 2 | 72.4630 | | | | 1 $\frac{1}{2}$ | 45.2062 | 2201 | 0185 | - 19.42 |
| 2 | 57.8205 | | | | 1 | 27.3982 | 4028 | 0068 | - 8.52 |
| 1 $\frac{1}{2}$ | 57.8034 | 8123 | 0145 | 17.46 | 2 | 27.2420 | | | |
| 2 | 54.7326 | | | | 1 $\frac{1}{2}$ | 11.8337 | 8494 | 0020 | - 1.50 |
| 1 $\frac{1}{2}$ | 53.9471 | 9554 | 0144 | 16.57 | 2 | 11.4915 | | | |

Weighted mean - 12.04
 V_a - 16.25
 V_d - .08
Curvature - .28
Radial velocity - 28.6

 ϵ HERCULIS 1774.1908, Aug. 7.
G. M. T. 15^h 35^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8210 | | | | 3 | 45.2291 | 2317 | 0070 | - 7.31 |
| 1 | 57.8904 | 8088 | 0180 | - 21.67 | 2 | 27.4238 | 4026 | 0100 | - 8.68 |
| 2 | 54.7349 | | | | 2 | 27.2676 | | | |
| 3 | 53.9647 | 9711 | 0013 | + 1.50 | 1 $\frac{1}{2}$ | 11.8833 | 8514 | 0080 | 0.60 |
| 2 | 53.1063 | | | | 2 | 11.5393 | | | |
| 2 | 45.2710 | | | | | | | | |

Weighted mean - 7.23
 V_a - 16.35
 V_d 17
Curvature - .28
Radial velocity - 24.0

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 1782.1908, Aug. 15.
G. M. T. 16^h 50^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9712 | ..... | ..... | ..... | 2 | 53.9308 | 3566 | .0132 | -15.19 |
| 1 | 72.8162 | .8545 | .0103 | -14.94 | 2 | 53.0801 | ..... | ..... | ..... |
| 2 | 72.4052 | ..... | ..... | ..... | 2 | 45.2550 | ..... | ..... | ..... |
| 2 | 57.7983 | ..... | ..... | ..... | 2 | 45.2055 | .2241 | .0146 | -15.24 |
| 1½ | 57.7814 | .8125 | .0143 | -17.21 | 1 | 27.3902 | .3902 | .0336 | -29.16 |
| 2 | 54.7181 | ..... | ..... | ..... | 2 | 27.2578 | ..... | ..... | ..... |

Weighted mean..... -17.44
 V_a -17.09
 V_d -24
Curvature..... -28

Radial velocity..... -35.0

 ϵ HERCULIS 1793.1908, Aug. 19.
G. M. T. 14^h 41^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 71.8997 | ..... | ..... | ..... | 1 | 66.5842 | .5905 | .0673 | -37.19 |
| 1 | 71.8180 | .8198 | .0673 | -29.58 | 2 | 61.4037 | ..... | ..... | ..... |
| 2 | 68.7255 | ..... | ..... | ..... | ½ | 61.1977 | .2033 | .0412 | -16.93 |

Weighted mean..... -30.09
 V_a -17.29
 V_d -15
Curvature..... -28

Radial velocity..... -47.8

 ϵ HERCULIS 1818.1908 Aug. 24.
G. M. T. 14^h 03^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9400 | ..... | ..... | ..... | 1 | 53.0350 | ..... | ..... | ..... |
| 1 | 72.7367 | .8053 | .0595 | -86.33 | 2 | 45.2000 | ..... | ..... | ..... |
| 2 | 72.3715 | ..... | ..... | ..... | 1½ | 45.1002 | .1737 | .0650 | -67.86 |
| 2 | 54.6722 | ..... | ..... | ..... | 1 | 27.2776 | .3336 | .0790 | -68.57 |
| 2 | 53.9557 | ..... | ..... | ..... | 2 | 27.1906 | ..... | ..... | ..... |
| 1 | 53.8285 | .9018 | .0680 | -78.27 | | | | | |

Weighted mean..... -74.44
 V_a -17.55
 V_d -15
Curvature..... -28

Radial velocity..... -92.4

SESSIONAL PAPER No. 25a

1908, Aug. 27.
G. M. T. 15^h 50^m

ε HERCULIS 1838.

Observed by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9994 | | | | 2 | 45.2716 | | | |
| 1 | 72.8367 | .8463 | .0185 | -26.84 | 1 | 45.2345 | .2365 | .0022 | -2.30 |
| 2 | 72.4383 | | | | 1 | 27.4216 | .3691 | .0135 | -11.72 |
| 2 | 57.8226 | | | | 2 | 27.2694 | | | |
| 1 | 57.8302 | .8344 | .076 | +9.15 | 1 | 11.8840 | .8453 | .0061 | -4.55 |
| 2 | 54.0265 | | | | 2 | 11.5462 | | | |
| 1½ | 54.9656 | .9679 | .0019 | -2.19 | | | | | |

Weighted mean..... - 5.82
 V_a 17.66
 V_d - .24
 Curvature..... - .28

Radial velocity..... -24.0

ε HERCULIS 1844.

1908, Aug. 28.
G. M. T. 14^h 07^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0320 | | | | 2 | 45.1750 | .1561 | .0826 | -86.23 |
| ½ | 72.8382 | .8158 | .0490 | -71.10 | ½ | 27.3755 | .3441 | .0685 | -59.46 |
| 2 | 72.4677 | | | | 2 | 27.2780 | | | |
| 2 | 54.0522 | | | | 1 | 11.7805 | .7394 | .1120 | -82.79 |
| 1 | 53.9207 | .8973 | .0725 | -81.45 | 2 | 11.5485 | | | |
| 2 | 45.2925 | | | | | | | | |

Weighted mean..... -80.80
 V_a -17.63
 V_d - .16
 Curvature..... - .28

Radial velocity..... -98.9

ε HERCULIS 1853.

1908, Aug. 31.
G. M. T. 13^h 52^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.0330 | | | | 1 | 45.2510 | .2530 | .0143 | +14.93 |
| 2 | 53.9830 | .9788 | .0100 | +11.51 | ½ | 27.4040 | .4166 | .0040 | +3.47 |
| 2 | 45.2716 | | | | 2 | 27.2340 | | | |

Weighted mean..... + 11.94
 V_a - 17.63
 V_d - .16
 Curvature..... - .28

Radial velocity..... - 6.1

9-10 EDWARD VII., A. 1910

ε HERCULIS 1866.

1908, Sept. 4.
G. M. T. 14^h 32^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.0286 | ..... | ..... | ..... | 2 | 45.2756 | ..... | ..... | ..... |
| 1½ | 53.9682 | 9684 | 0014 | - 2.03 | ½ | 45.2387 | 2367 | 0020 | - 2.09 |

Weighted mean..... 2.05

V_a..... 17.56V_d..... 22

Curvature..... 28

Radial velocity..... 20.1

ε HERCULIS 1903.

1908, Oct. 1.
G. M. T. 13^h 12^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9627 | ..... | ..... | ..... | 2 | 53.0938 | ..... | ..... | ..... |
| 1½ | 72.8369 | 8850 | 0202 | + 29.31 | 2 | 45.2707 | ..... | ..... | ..... |
| 2 | 72.3935 | ..... | ..... | ..... | ½ | 45.2698 | 2727 | 0340 | 35.96 |
| 2 | 54.7217 | ..... | ..... | ..... | 2 | 43.5385 | ..... | ..... | ..... |
| ½ | 53.9629 | 9891 | 0121 | 13.93 | 1 | 43.0812 | 0811 | 0308 | + 31.58 |

Weighted mean..... + 28.39

V_a..... 13.58V_d..... 23

Curvature..... 28

Radial velocity..... + 14.3

ε HERCULIS 1903.*

1908, Oct. 1.
G. M. T. 13^h 12^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8380 | ..... | ..... | ..... | 2 | 54.0527 | ..... | ..... | ..... |
| 1½ | 57.8367 | 8255 | 0113 | - 13.60 | ½ | 45.3017 | 2673 | 0286 | - 31.95 |
| 2 | 53.0120 | 9881 | 0183 | - 21.06 | 2 | 45.3080 | ..... | ..... | ..... |

Weighted mean..... + 22.17

V_a..... 13.58V_d..... 23

Curvature..... 28

Radial velocity..... + 8.1

Check measurement.

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ε HERCULIS 1905.

1908. Oct. 2.
G. M. T. 12^h 23^mObserved by T. H. PARKER.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9333 | | | | $\frac{1}{2}$ | 53 9743 | 0083 | 0385 | 44.31 |
| $\frac{1}{2}$ | 72 8133 | 8888 | 0240 | 34.82 | 2 | 53 0845 | | | |
| 2 | 72 3735 | | | | 2 | 45 2615 | | | |
| 2 | 54 7063 | | | | $\frac{1}{2}$ | 45 2510 | 2631 | 0244 | +25.47 |

Weighted mean +34.86

 V_a 16.17 V_d 19

Curvature 28

Radial velocity +18.2

ε HERCULIS 1905.*

1908. Oct. 2.
G. M. T. 12^h 23^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|-----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73 0219 | | | | 1 | 54 0557 | 9920 | 0222 | +25.55 |
| $\frac{1}{2}$ | 72 9047 | 8923 | 0275 | +39.50 | 2 | 45 3540 | | | |
| 2 | 72 4605 | | | | 1 $\frac{1}{2}$ | 45 3672 | 2868 | 0481 | +50.22 |
| 2 | 54 0925 | | | | | | | | |

Weighted mean +40.28

 V_a 16.17 V_d 19

Curvature 28

Radial velocity +23.6

* Check measurement.

ε HERCULIS 1906.

1908. Oct. 2.
G. M. T. 13^h 18^mObserved by T. H. PARKER.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9878 | | | | 2 | 45 2706 | | | |
| $\frac{1}{2}$ | 72 8491 | 8716 | 0068 | +9.86 | 1 | 45 2536 | | 0179 | 18.69 |
| 2 | 72 4218 | | | | $\frac{1}{2}$ | 27 4469 | 3999 | 0127 | -11.02 |
| 2 | 54 7350 | | | | 2 | 27 2936 | | | |
| $\frac{1}{2}$ | 53 9915 | 9995 | 0297 | +34.18 | $\frac{1}{2}$ | 15 5485 | 4771 | 0040 | +2.93 |
| 2 | 53 1029 | | | | 2 | 15 4700 | | | |

Weighted mean +12.23

 V_a 16.17 V_d 23

Curvature 28

Radial velocity 4.4

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 1906.*1908. Oct. 2
G. M. T. 13^h 18^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73 0126 | | | | $\frac{1}{2}$ | 45 2729 | 2434 | 0047 | - 4 81 |
| $\frac{1}{2}$ | 72 8790 | 8759 | 0111 | -16 11 | 2 | 45 3031 | | | |
| $\frac{1}{2}$ | 72 4515 | | | | $\frac{1}{2}$ | 27 4884 | 4016 | 0110 | - 9 55 |
| $\frac{1}{2}$ | 54 0508 | | | | 2 | 27 3237 | | | |
| $\frac{1}{2}$ | 53 9882 | 9662 | 0036 | - 4 14 | | | | | |

Weighted mean..... - 1 15
 V_a -16 17
 V_d - 23
 Curvature..... - 28
 Radial velocity..... -15 5

* Check measurement.

 ϵ HERCULIS 1917.1908. Oct. 5
G. M. T. 12^h 45^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 53 9338 | | | | 1 | 53 9042 | 9992 | 0294 | +33 84 |

Weighted mean..... -33 84
 V_a -15 21
 V_d - 22
 Curvature..... -28
 Radial velocity..... -18 1

 ϵ HERCULIS 1926.1908. Oct. 12.
G. M. T. 14^h 15^mObserved by T. H. PARKER.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7809 | | | | 2 | 45 3392 | | | |
| $\frac{1}{2}$ | 53 0112 | 9684 | 0014 | - 1 61 | $\frac{1}{2}$ | 45 2745 | 2089 | 0298 | -31 11 |
| 2 | 53 1586 | | | | | | | | |

Weighted mean..... -16 36
 V_a -12 99
 V_d - 28
 Curvature..... - 28
 Radial velocity..... -29 9

SESSIONAL PAPER No. 25a

ε HERCULIS 1926.*

1908, Oct. 12.
G. M. T. 14^h 15^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9282 | ..... | ..... | ..... | 1 | 53 9142 | 9648 | 0050 | 5 55 |
| 2 | 72 7570 | 8383 | 0255 | 38 45 | 2 | 45 2412 | ..... | ..... | ..... |
| 2 | 72 3640 | ..... | ..... | ..... | 2 | 45 1955 | 2281 | 0106 | 11 06 |
| 2 | 53 9777 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean 11 73
 V_a 12 99
 V_d 28
 Curvature 28

* Check measurement.

Radial velocity -25 3

ε HERCULIS 1961.

1908, Nov. 13.
G. M. T. 10^h 33^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9540 | ..... | ..... | ..... | 1 1/2 | 45 1808 | 1763 | 0725 | 75 91 |
| 2 | 72 7900 | 7980 | 0207 | -30 08 | 1 | 27 4609 | 4488 | 0394 | 34 36 |
| 2 | 72 3992 | ..... | ..... | ..... | 2 | 27 3340 | ..... | ..... | ..... |
| 2 | 54 0249 | ..... | ..... | ..... | 1/2 | 11 8665 | 8626 | 1378 | -103 76 |
| 1 | 54 9106 | 9010 | 0556 | 64 16 | 2 | 11 6620 | ..... | ..... | ..... |
| 2 | 45 2941 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean -62 07
 V_a 4 70
 V_d 23
 Curvature 28

Radial velocity -67 3

ε HERCULIS 1961.*

1908, Nov. 13.
G. M. T. 10^h 33^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9915 | ..... | ..... | ..... | 2 | 48 8173 | ..... | ..... | ..... |
| 1/2 | 72 8067 | 8233 | 0415 | -60 22 | 1/2 | 48 1143 | 0670 | ..... | ..... |
| 2 | 72 4317 | ..... | ..... | ..... | 2 | 45 3301 | ..... | ..... | ..... |
| 2 | 54 7682 | ..... | ..... | ..... | 1 | 45 2254 | 1689 | 0698 | 72 87 |
| 1 | 53 9192 | 8912 | 0603 | 62 42 | 1 | 27 4192 | 3334 | 0792 | -67 74 |
| 2 | 53 1417 | ..... | ..... | ..... | 2 | 27 3324 | ..... | ..... | ..... |

Weighted mean -66 75
 V_a 4 69
 V_d 25
 Curvature 28

* Check measurement.

Radial velocity -71 8

9-10 EDWARD VII., A. 1910

ε HERCULIS 1961.*

1908. Nov. 13.
G. M. T. 10^h 33^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9300 | | | | 2 | 53.0847 | | | |
| $\frac{1}{2}$ | 72.7524 | 7849 | 0338 | -48.11 | 2 | 45.2672 | | | |
| 2 | 72.3700 | | | | 1 | 45.1730 | 1894 | 0593 | 62.09 |
| 2 | 54.7057 | | | | $\frac{1}{2}$ | 11.8557 | 8791 | 1213 | -91.95 |
| $\frac{1}{4}$ | 53.8622 | 8807 | 0759 | 87.59 | 2 | 11.6345 | | | |

Weighted mean..... -68.24
 V_a -4.70
 V_d -23
 Curvature..... -28

* Check measurement.

Radial velocity..... -73.4

ε HERCULIS 1983.

1908. Nov. 26.
G. M. T. 10^h 07^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9887 | | | | 2 | 53.1422 | | | |
| 2 | 72.4267 | | | | 2 | 45.3295 | | | |
| 2 | 57.8410 | | | | $\frac{1}{2}$ | 45.2686 | 2237 | 0250 | -26.17 |
| $\frac{1}{4}$ | 57.8284 | 7837 | 0210 | -25.32 | 2 | 27.3610 | | | |
| 2 | 54.7670 | | | | 2 | 11.6692 | | | |
| 1 | 53.9637 | 9227 | 0339 | 39.12 | | | | | |

Weighted mean..... -29.54
 V_a -79
 V_d -25
 Curvature..... -28

Radial velocity..... -30.9

ε HERCULIS 1993.

1908. Dec. 2.
G. M. T. 11^h 05^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0015 | | | | 2 | 54.0327 | 9273 | 0159 | 18.28 |
| $\frac{1}{2}$ | 72.8197 | 7353 | 0368 | -53.51 | 2 | 45.3945 | | | |
| 2 | 72.4371 | | | | 1 | 45.3182 | 2173 | 0416 | -43.68 |
| 2 | 54.1072 | | | | | | | | |

Weighted mean..... -30.57
 V_a +1.12
 V_d -28
 Curvature..... -28

Radial velocity..... -30.0

SESSIONAL PAPER No. 25a

HERCULIS 2263.

1909. Feb. 8.
G. M. T. 22^h 08^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72 8987 | | | | 1 | 45 2382 | 1897 | 0692 | 79 51 |
| $\frac{1}{2}$ | 72 7145 | 7305 | 0416 | - 60 49 | $\frac{1}{2}$ | 27 5582 | 5658 | 0560 | 49 56 |
| 2 | 72 3414 | | | | 2 | 27 4495 | | | |
| 2 | 54 0360 | | | | $\frac{1}{2}$ | 12 1170 | 1696 | 0391 | - 29 56 |
| 1 | 53 9233 | 8891 | 0541 | 62 57 | 2 | 11 8145 | | | |
| 2 | 45 3421 | | | | | | | | |

Weighted mean - 60 54

 V_{θ} + 17 19 V_d - 16

Curvature - 28

Radial velocity - 43 5

HERCULIS 2264.

1909. Feb. 8.
G. M. T. 23^hObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72 8680 | | | | 1 | 45 2202 | 2118 | 0471 | - 54 12 |
| $\frac{1}{2}$ | 72 6942 | 7400 | 0321 | - 46 67 | 1 | 27 5152 | 5061 | 0551 | - 49 29 |
| 1 | 72 3157 | | | | 2 | 27 4062 | | | |
| 2 | 54 0053 | | | | 1 | 12 0368 | 0711 | 0776 | - 58 66 |
| $1\frac{1}{2}$ | 53 8918 | 8878 | 0554 | - 64 07 | 2 | 11 7743 | | | |
| 2 | 45 3029 | | | | | | | | |

Weighted mean - 56 30

 V_{θ} + 17 19 V_d + 12

Curvature - 28

Radial velocity - 39 3

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 2305.1909. Feb. 22.
G. M. T. 21^h 34^mObserved by J. B. CANNON.
Measured by W. E. HARPER

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9872 | ..... | ..... | ..... | $\frac{1}{2}$ | 53.9658 | .9111 | .0321 | -37.13 |
| $\frac{1}{2}$ | 72.8275 | .7571 | .0150 | -21.81 | 2 | 45.3275 | ..... | ..... | ..... |
| 2 | 72.4233 | ..... | ..... | ..... | 1 | 45.2636 | .2295 | .0294 | -30.87 |
| 2 | 57.8428 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.4794 | .4953 | .0665 | -58.22 |
| $1\frac{1}{2}$ | 57.8125 | .7522 | .0303 | -36.63 | 2 | 27.3812 | ..... | ..... | ..... |
| 2 | 54.0565 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean - 36.09

 V_a - 17.95 V_d - .15

Curvature - .28

Radial velocity - 18.2

 ϵ HERCULIS 2306.1909. Feb. 22.
G. M. T. 22^h 36^mObserved by J. B. CANNON.
Measured by W. E. HARPER

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9687 | ..... | ..... | ..... | 2 | 45.3155 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8071 | .7544 | .0177 | -25.74 | 1 | 45.2637 | .2415 | .0174 | -18.27 |
| 1 | 72.4092 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.5020 | .5276 | .0342 | -29.93 |
| 1 | 57.7942 | ..... | ..... | ..... | 2 | 27.3725 | ..... | ..... | ..... |
| 2 | 57.8290 | .7477 | .0348 | -42.05 | 1 | 11.9835 | .0905 | .0582 | -44.00 |
| 2 | 54.0450 | ..... | ..... | ..... | 2 | 11.7002 | ..... | ..... | ..... |
| 1 | 53.9530 | .9100 | .0332 | -38.40 | | | | | |

Weighted mean - 34.12

 V_a + 17.95 V_d + .09

Curvature - .28

Radial velocity - 16.4

SESSIONAL PAPER No. 25a

ε HERCULIS 2327.

1909, March 2.
G. M. T. 21^h 12^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.3387 | ..... | ..... | ..... | 2 | 45.2988 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8030 | 7800 | 0079 | 11.49 | $1\frac{1}{2}$ | 45.3043 | 2991 | 0402 | +42.21 |
| 2 | 72.3801 | ..... | ..... | ..... | $\frac{1}{2}$ | 12.6685 | 1891 | 0404 | +30.54 |
| 2 | 54.0227 | ..... | ..... | ..... | 2 | 11.6875 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 53.9890 | 9681 | 0249 | +28.70 | | | | | |

Weighted mean..... +31.76

 V_{α} +17.90 V_{δ} +.14

Curvature..... - 28

Radial velocity..... - 49.5

ε HERCULIS 2328.

1909, March 2.
G. M. T. 22^h 26^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 53.9635 | ..... | ..... | ..... | 2 | 45.2644 | ..... | ..... | ..... |
| 1 | 53.9260 | 9343 | 0091 | -10.52 | $\frac{1}{2}$ | 45.2350 | 2642 | 0053 | +5.56 |

Weighted mean..... 5.16

 V_{α} +17.90 V_{δ} +.05

Curvature..... - 28

Radial velocity..... - 12.5

ε HERCULIS 2370*.

1909, March 13.
G. M. T. 18^h 35^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 50.9370 | ..... | ..... | ..... | $\frac{1}{2}$ | 34.7430 | 34.7193 | 1038 | 100.00 |
| 1 | 50.8242 | 8081 | 0804 | -93.05 | 2 | 34.6975 | ..... | ..... | ..... |

Weighted mean..... -95.36

 V_{α} +17.44 V_{δ} - 19

Curvature..... - 30

Radial velocity..... - 78.0

* This plate and all following were taken by the new single-prism Spectroscope.

9-10 EDWARD VII., A. 1910

 ϵ HERCULIS 2371.1909. March 13.
G. M. T. 19^h 23^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 58° 8462 | ..... | ..... | ..... | 1 | 50° 8549 | 8347 | 0538 | - 62.27 |
| $\frac{1}{2}$ | 58° 7184 | 6911 | 0741 | - 94.51 | $\frac{1}{2}$ | 34° 7589 | 7401 | 0820 | - 79.00 |
| 2 | 50° 9411 | ..... | ..... | ..... | 2 | 34° 6926 | ..... | ..... | ..... |

Weighted mean..... - 71.66

 V_a + 17.44 V_d + 19

Curvature..... - 30

Radial velocity..... - 54.3

 ϵ HERCULIS 2374.1909. March 15.
G. M. T. 19^h 32^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 58° 8228 | ..... | ..... | ..... | 2 | 50° 9196 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 58° 7768 | 7729 | 0077 | + 9.82 | $\frac{1}{2}$ | 50° 9081 | 9094 | 0209 | - 24.19 |

Weighted mean..... - 19.40

 V_a + 17.16 V_d + 18

Curvature..... - 30

Radial velocity..... - 36.4

 ϵ HERCULIS 2385.1909. March 15.
G. M. T. 20^h 30^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 58° 8349 | ..... | ..... | ..... | 1 | 50° 9261 | 9091 | 0206 | - 23.84 |
| $\frac{1}{2}$ | 58° 7924 | 7764 | 0112 | + 14.29 | $\frac{1}{2}$ | 34° 8678 | 8413 | 0192 | + 18.50 |
| 2 | 50° 9379 | ..... | ..... | ..... | 2 | 34° 7003 | ..... | ..... | ..... |

Weighted mean..... + 21.36

 V_a + 17.16 V_d + 18

Curvature..... - 30

Radial velocity..... + 38.4

SESSIONAL PAPER No. 25a

 ϵ HERCULIS 2454.1909, March 21.
G. M. T. 20^h 05^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 58.8306 | | | | 1 | 50.9084 | 9091 | 0206 | +23.84 |
| $\frac{1}{2}$ | 58.7836 | 7720 | 0068 | + 8.67 | $\frac{1}{2}$ | 34.7992 | 8274 | 0053 | + 5.11 |
| 2 | 50.9202 | | | | 2 | 34.6456 | | | |

Weighted mean. -15.34

 V_a -14.93 V_d - .06

Curvature30

Radial velocity -30.0

 ϵ HERCULIS 2455.1909, March 31.
G. M. T. 20^h 39^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 58.8294 | | | | 1 | 50.9111 | 9091 | 0206 | +23.84 |
| $\frac{1}{2}$ | 58.8022 | 7917 | 0265 | +33.80 | $\frac{1}{2}$ | 34.7739 | 8005 | 0216 | -20.90 |
| 2 | 50.9229 | | | | 2 | 34.6522 | | | |

Weighted mean. +15.15

 V_a +14.93 V_d + .06

Curvature - .30

Radial velocity +29.8

9-10 EDWARD VII., A. 1910

OBSERVING RECORD AND DETAILED MEASURES OF η BOÖTIS.

P.—PLASKETT.
 Pl.—PARKER.
 H.—HARPER.
 C.—CANNON.
 T.—TRIBBLE.

RECORD OF SPECTROGRAMS.

| Star. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure. G. M. T. | | Duration. | Hour Angle at end. | TEMPERATURE. | | | | Slit Width. | Seeing. | Observer. |
|----------------|------------------|---------|-----------|-------|---------------------------------|----|-----------|--------------------------|--------------|--------|------------|--------|-------------|-----------------|----------------|
| | | | | | | | | | Room. | | Prism Box. | | | | |
| | | | | | | | | | Beg. | End. | Beg. | End. | | | |
| | | | | 1906. | h. m. | m. | h. m. | | Fahre | nheit. | Centi | grade. | | | |
| η Boötis. | 308 | IL | (Seed 27) | June | 25 15 | 55 | 35 3 | 30W. | 65 0 | 64 0 | 22 7 | 22 8 | .001 | Poor... | P |
| " | 313 | " | " | " | 27 14 | 35 | 35 2 | 15W. | 75 6 | 74 0 | 27 1 | 27 0 | .001 | Fair.... | P |
| " | 318c | " | " | " | 29 14 | 21 | 18 2 | 10W. | 77 4 | 76 2 | 27 0 | 27 0 | .0009 | " | P |
| " | 326 | " | " | July | 4 14 | 50 | 60 3 | 15W. | 62 5 | 60 9 | 21 3 | 21 4 | .001 | Fair to good... | P |
| " | 333 | " | " | " | 6 15 | 00 | 70 3 | 40W. | 71 5 | 68 0 | 25 3 | 25 4 | .001 | Fair.... | P |
| " | 366 | " | " | Aug. | 6 14 | 05 | 70 4 | 45W. | 78 0 | 74 0 | 28 8 | 28 8 | .001 | Good... | P |
| " | 372 | " | " | " | 8 14 | 15 | 75 5 | 10W. | 80 8 | 77 5 | 29 5 | 29 3 | .001 | Fair.... | P |
| | | | | 1907. | | | | | | | | | | | |
| " | 657 | " | " | Mar. | 8 18 | 45 | 30 | 50E. | 26 5 | 25 6 | 1 3 | 1 5 | .0013 | Fair.... | P |
| " | 670 | " | " | " | 20 18 | 32 | 45 | 10E. | 28 6 | 28 3 | 2 8 | 2 9 | .0013 | Good... | P |
| " | 691 | " | " | Apr. | 3 18 | 02 | 35 | 15W. | 44 0 | 40 2 | 9 8 | 10 1 | .001 | Poor... | P |
| " | 731 | " | " | " | 19 18 | 35 | 10 1 | 37W. | 34 8 | 34 5 | 10 4 | 10 4 | .0013 | Clouds. | P |
| " | 739 | " | " | " | 26 17 | 30 | 30 1 | 07W. | 42 0 | 40 4 | 9 0 | 9 0 | .0013 | Fair.... | P |
| " | 752 | " | " | May | 7 14 | 20 | 20 1 | 30E. | 50 5 | 50 0 | 16 1 | 16 1 | .0013 | " | H |
| " | 760 | IIIL | " | " | 14 17 | 55 | 34 2 | 05W. | 11 7 | 11 7 | 15 0 | 15 0 | .0012 | Very poor... | H |
| " | 764 | " | " | " | 20 16 | 25 | 55 1 | 45W. | 6 0 | 5 3 | 9 2 | 9 2 | .0012 | Unst'dy | H |
| " | 769 | " | " | " | 22 16 | 51 | 47 2 | 20W. | 10 5 | 10 5 | 13 2 | 13 2 | .0012 | Cloudy. | P |
| " | 774 | IL | " | " | 23 14 | 08 | 16 | 37E. | 15 5 | 15 0 | 17 3 | 17 3 | .0012 | Fair.... | H |
| " | 779 | " | " | " | 24 15 | 01 | 12 | 20W. | 11 8 | 12 0 | 16 4 | 16 4 | .001 | Good... | P |
| " | 793 | " | " | " | 29 16 | 46 | 27 2 | 30W. | 8 0 | 8 0 | 14 5 | 14 5 | .001 | Cloudy. | P |
| " | 797 | " | " | " | 31 14 | 54 | 12 | 45W. | 15 2 | 15 2 | 19 0 | 19 0 | .001 | Good... | P |
| " | 812 | " | " | June | 10 13 | 35 | 35 1 | 48W. | 16 6 | 15 6 | 18 2 | 18 0 | .0009 | " | P |
| " | 868 | " | " | " | 21 14 | 27 | 25 1 | 40W. | 25 4 | 24 6 | 28 9 | 28 9 | .001 | Hazy | P |
| " | 891 | " | " | " | 27 14 | 55 | 30 2 | 35W. | 22 0 | 22 0 | 24 5 | 24 5 | .0012 | Fair.... | H |
| " | 918 | " | " | July | 8 15 | 09 | 18 3 | 30W. | 21 5 | 21 1 | 22 4 | 22 4 | .0012 | " | P |
| " | 950 | " | " | " | 18 13 | 57 | 26 3 | 00W. | 27 0 | 26 0 | 28 5 | 28 5 | .0012 | Very hazy... | T |
| " | 972 | " | " | Aug. | 1 13 | 39 | 25 3 | 37W. | 22 2 | 21 0 | 25 2 | 25 2 | .001 | Hazy | H |
| " | 990 | IIIL | " | " | 7 13 | 58 | 50 4 | 30W. | 23 1 | 22 0 | 24 1 | 24 1 | .0015 | Poor... | P |
| | | | | 1908. | | | | | | | | | | | |
| " | 1231 | IL | " | Jan. | 14 22 | 00 | 26 1 | 10E. | -16 5 | -18 0 | -5 2 | -5 5 | .001 | Hazy... | H |
| " | 1294 | IIIL | " | " | 27 20 | 12 | 50 1 | 52E. | -20 0 | -18 0 | -15 3 | -15 3 | .0013 | Good... | H |
| " | 1307 | " | " | " | 29 21 | 14 | 62 1 | 07E. | -25 3 | -25 5 | -13 7 | -13 7 | .0013 | Unst'dy | P |
| " | 1332 | " | " | Feb. | 17 22 | 30 | 40 1 | 45W. | -17 5 | -18 0 | -10 5 | -10 5 | .0015 | Good... | P |
| " | 1357 | " | " | " | 24 19 | 06 | 47 1 | 20E. | -16 5 | -15 5 | -19 0 | -18 6 | .0013 | Unst'dy | H |
| " | 1446 | " | " | Mar. | 30 30 | 52 | 40 3 | 50W. | 0 5 | 0 5 | 6 0 | 6 0 | .002 | Fair.... | H |
| " | 1513 | " | " | May | 4 18 | 13 | 55 2 | 40W. | 8 0 | 7 0 | 13 4 | 13 3 | .0017 | Good... | P ^H |
| " | 1533 | " | " | " | 25 15 | 58 | 64 1 | 50W. | 21 3 | 20 5 | 25 6 | 25 4 | .0016 | " | P ^H |
| " | 1557 | " | " | " | 23 16 | 00 | 50 1 | 45W. | 21 5 | 20 7 | 25 7 | 25 6 | .0015 | Fair.... | P |
| " | 1621 | " | " | June | 22 14 | 10 | 30 2 | 35W. | 20 0 | 19 6 | 24 0 | 23 8 | .0015 | " | P |
| " | 1663 | " | " | July | 6 14 | 40 | 80 3 | 25W. | 25 3 | 24 8 | 26 8 | 26 3 | .0015 | Good... | P |
| " | 1710 | " | " | " | 15 14 | 41 | 102 4 | 11W. | 19 5 | 18 0 | 21 8 | 21 6 | .0015 | Cloudy. | C |
| " | 1792 | " | " | Aug. | 19 13 | 18 | 60 4 | 47W. | 18 8 | 16 5 | 24 3 | 23 8 | .0018 | Good... | H |
| " | 1867 | " | " | Sept. | 7 12 | 57 | 65 5 | 40W. | 18 2 | 17 6 | 21 4 | 21 2 | .0015 | Fair.... | P |
| | | | | 1909. | | | | | | | | | | | |
| " | 2115 | " | " | Jan. | 7 23 | 23 | 60 | 10W. | -20 0 | -20 5 | -13 6 | -13 6 | .0016 | Fair.... | P |
| " | 2209 | " | " | " | 30 18 | 37 | 45 3 | 20E. | -8 3 | -8 5 | -2 8 | -2 9 | .0016 | Unst'dy | P |
| " | 2283 | " | " | Feb. | 17 20 | 30 | 62 | 00 | -12 0 | -12 0 | -1 3 | -1 3 | .0015 | Good... | C |
| " | 2396 | " | " | Mar. | 20 17 | 00 | 60 1 | 30E. | -2 3 | -3 3 | 4 6 | 4 6 | .0015 | Fair... | P |

SESSIONAL PAPER No. 25a

1906. June 25.
G. M. T. 15^h 55^m η BOÖTIS 308.Observed by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 3 | 65.1413 | 4583.661 | | | | | 13 | 46.0370 | 4376.165 | | | | |
| 2 | 62.3546 | 4550.101 | .165 | .766 | .309 | +26.28 | 13 | 45.4280 | 4370.332 | .276 | .856 | .420 | 30.61 |
| 1 | 60.7590 | 4531.441 | .473 | .201 | .272 | 17.99 | 13 | 41.8841 | 4337.216 | | | | |
| 1 | 60.5605 | 4529.147 | .171 | .807 | .364 | 24.16 | 1 | 39.8944 | 4319.219 | .191 | .817 | .374 | 38.64 |
| 2 | 60.0625 | 4523.302 | .318 | .055 | .263 | 17.43 | 13 | 39.7049 | 4317.527 | .503 | .068 | .455 | 30.21 |
| 1 | 57.5179 | 4494.721 | | | | | 13 | 39.4547 | 4315.298 | | | | |
| 1 | 54.9606 | 4466.816 | | | | | 2 | 39.4909 | 4315.620 | .600 | .178 | .422 | 29.33 |
| 1 | 54.2971 | 4459.723 | .651 | .304 | .347 | 23.32 | 2 | 37.6639 | 4294.322 | | | | |
| 1 | 54.2635 | 4459.366 | | | | | 33 | 33.1023 | 4260.796 | .820 | .503 | .317 | 22.30 |
| 1 | 53.8823 | 4455.320 | .240 | .162 | .278 | 18.71 | 1 | 29.7582 | 4233.629 | .685 | .462 | .223 | 15.79 |
| 1 | 51.2524 | 4427.927 | .855 | .420 | .435 | 29.45 | 1 | 31.9013 | 4250.924 | .972 | .643 | .329 | +23.21 |
| 1 | 49.0104 | 4405.271 | .199 | .951 | .320 | 21.78 | 2 | 22.9884 | 4181.569 | | | | |

Weighted mean +23.08

 V_a -24.87 V_d -25

Curvature -28

Radial velocity -2.3

 η BOÖTIS 313.1906. June 27.
G. M. T. 14^h 35^mObserved by J. S. PLASKETT.
Measured by W. E. HAPFER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 70.0228 | 4549.704 | | | | | 1 | 58.7715 | 4425.974 | .982 | .608 | .374 | 25.31 |
| 2 | 70.0646 | 4550.199 | .143 | .766 | .377 | +24.84 | 13 | 57.7472 | 4415.579 | .571 | .244 | .327 | 22.20 |
| 2 | 68.8922 | 4536.420 | .408 | .965 | .443 | 29.28 | 23 | 56.7110 | 4405.198 | .194 | .951 | .243 | 16.80 |
| 1 | 68.4773 | 4531.556 | .552 | .202 | .350 | 23.13 | 23 | 56.6837 | | | | | |
| 1 | 68.3445 | 4530.057 | .057 | .781 | .273 | 18.04 | 13 | 55.7498 | 4395.689 | .696 | .286 | .410 | 27.96 |
| 2 | 68.2790 | 4529.300 | .297 | .807 | .490 | 32.38 | 1 | 54.5449 | 4383.928 | .970 | .720 | .250 | 17.07 |
| 38 | 68.2356 | | | | | | 1 | 54.5162 | 4383.650 | | | | |
| 1 | 67.7616 | 4523.337 | .345 | .855 | .490 | 32.38 | 1 | 53.1281 | 4370.320 | .356 | .856 | .500 | 31.30 |
| 3 | 65.2295 | 4494.746 | | | | | 1 | 52.9142 | 4368.285 | .320 | .840 | .480 | 32.92 |
| 1 | 64.1575 | 4482.928 | .924 | .434 | .490 | 32.88 | 3 | 51.2105 | 4352.272 | .312 | .606 | .366 | 21.08 |
| 1 | 63.5802 | 4476.631 | .631 | .214 | .420 | 28.09 | 3 | 48.3264 | 4325.902 | | | | |
| 2 | 63.5399 | 4476.193 | | | | | 13 | 47.8181 | 4321.348 | .368 | .992 | .376 | 26.05 |
| 1 | 63.2805 | 4473.381 | .377 | .857 | .420 | 28.10 | 12 | 47.1641 | 4315.529 | .545 | .178 | .367 | 25.46 |
| 2 | 62.6605 | 4466.698 | | | | | 38 | 46.3197 | | | | | |
| 2 | 59.7122 | 4435.639 | .654 | .184 | .470 | 31.77 | 1 | 46.3442 | 4308.296 | .296 | .023 | .273 | 18.97 |
| 1 | 58.9422 | 4427.719 | .730 | .420 | .310 | 20.98 | 2 | 46.1418 | 4306.521 | .513 | .153 | .360 | 25.02 |

Weighted mean +25.87

 V_a -25.19 V_d -14

Curvature -50

Radial velocity 0.0

9-10 EDWARD VII., A. 1910

 η BOÖTIS 318c.1906. June 29.
G. M. T. 14^h 21^mObserved by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| W.L. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | W.L. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 23 | 65-1913 | 4584 018 | | | | | 13 | 46 8204 | 4383-596 | | | | |
| 2 | 62-3803 | 4550-121 | 205 | 766 | 439 | +28-93 | 14 | 45-5865 | 4371-738 | 866 | 312 | 494 | 29-78 |
| 2 | 62-3321 | 4549-552 | | | | | 1 | 45-4158 | 4370-111 | 177 | 856 | 321 | 22-03 |
| 3 | 60-7998 | 4531-584 | 664 | 292 | 462 | 30-59 | 1 | 45-2187 | 4368-238 | 302 | 840 | 462 | 31-84 |
| 1 | 60-5480 | 4528-712 | | | | | 1 | 42-2886 | 4340-901 | 941 | 634 | 307 | 21-20 |
| 1 | 60-0766 | 4523-289 | | | | | 13 | 39-4436 | 4315-255 | | | | |
| 14 | 57-5359 | 4494-635 | 377 | 855 | 522 | 34-61 | 1 | 38-6060 | 4308-394 | 390 | 023 | 367 | 25-53 |
| 14 | 54-2713 | 4459-185 | | | | | 3 | 37-0462 | 4294-299 | | | | |
| 14 | 53-9012 | 4455-264 | 384 | 962 | 422 | 28-40 | 1 | 35-7398 | 4283-122 | 106 | 721 | 385 | 26-95 |
| 1 | 51-5610 | 4430-869 | 985 | 678 | 307 | 20-78 | 13 | 33-0517 | 4260-643 | | | | |
| 1 | 50-0623 | 4415-601 | 709 | 233 | 416 | 28-25 | 1 | 28-9306 | 4227-475 | 463 | 010 | 453 | 32-12 |
| 14 | 50-0089 | 4415-084 | | | | | 1 | 25-2131 | 4198-823 | 819 | 403 | | +28-78 |
| 2 | 49-0242 | 4405-227 | 331 | 951 | 380 | 25-87 | 2 | 22-9474 | 4181-919 | | | | |
| 1 | 46-8536 | 4383-917 | 001 | 720 | 281 | 20-02 | | | | | | | |

Weighted mean + 27-55

 V_a - 25-31 V_d - 14

Curvature..... - 28

Radial velocity + 1-8

 η BOÖTIS 326.1906. July 4.
G. M. T. 14^h 50^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| W.L. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | W.L. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 12 | 47-9535 | 4321-280 | 292 | 992 | 300 | +20-97 | 1 | 62-1243 | 4459-686 | 724 | 304 | 420 | 28-22 |
| 12 | 72-9821 | 4584-067 | | | | | 2 | 61-7083 | 4455-266 | 300 | 962 | 338 | 22-74 |
| 1 | 72-0410 | 4572-552 | 528 | 156 | 372 | 24-32 | 1 | 61-3025 | 4450-975 | 097 | 654 | 443 | 29-81 |
| 2 | 70-1726 | 4550-127 | 126 | 766 | 360 | 23-68 | 2 | 59-6672 | 4427-735 | 743 | 420 | 323 | 21-86 |
| 28 | 70-1316 | | | | | | 2 | 57-8787 | 4415-645 | 638 | 293 | 345 | 23-42 |
| 2 | 68-9985 | 4536-325 | 325 | 965 | 360 | 23-79 | 2 | 56-8425 | 4405-249 | 251 | 951 | 300 | 20-43 |
| 1 | 68-3839 | 4529-186 | 187 | 807 | 380 | 25-15 | 38 | 56-8102 | | | | | |
| 3 | 68-3512 | 4528-807 | | | | | 2 | 55-8790 | 4395-702 | 710 | 286 | 424 | 28-91 |
| 1 | 67-8624 | 4523-173 | 165 | 855 | 310 | 20-55 | 3 | 54-6865 | 4384-041 | 060 | 720 | 340 | 23-25 |
| 2 | 65-9783 | 4501-798 | 786 | 448 | 338 | 22-47 | 2 | 54-6501 | 4383-688 | | | | |
| 2 | 65-3427 | 4494-706 | | | | | 2 | 53-4072 | 4371-721 | 752 | 312 | 440 | 30-18 |
| 2 | 63-6949 | 4476-593 | 584 | 214 | 370 | 24-75 | 1 | 53-0457 | 4368-273 | 300 | 840 | 460 | 31-55 |
| 2 | 63-6582 | 4476-195 | | | | | 2 | 51-3477 | 4352-284 | 308 | 006 | 302 | 20-80 |
| 2 | 63-3995 | 4473-387 | 407 | 957 | 450 | 30-15 | 3 | 50-1222 | 4340-944 | 960 | 634 | 326 | 22-49 |
| 2 | 62-7750 | 4466-648 | | | | | 3 | 48-4705 | 4325-922 | | | | |
| 1 | 62-8070 | 4466-982 | 061 | 771 | 290 | 19-45 | 3 | 47-3080 | 4315-523 | 523 | 1-78 | 345 | +23-94 |
| 2 | 62-6324 | 4465-118 | 158 | 712 | 446 | 29-92 | 38 | 46-4662 | | | | | |

Weighted mean + 24-70

 V_a - 25-68 V_d - 21

Curvature..... - 50

Radial velocity - 1-7

SESSIONAL PAPER No. 25a

 γ BOÖTIS 333.1906. July 6.
G. M. T. 15^h 0^mObserved by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 65.1677 | 4584.687 | ... | ... | ... | ... | 2 | 49.0105 | 4405.903 | 327 | 951 | 376 | 25.60 |
| 1 | 64.2090 | 4572.978 | 370 | 156 | 214 | -14.03 | 2 | 49.9783 | 4415.602 | ... | ... | ... | ... |
| 12 | 62.3721 | 4550.733 | 149 | 766 | 383 | 25.23 | 12 | 46.8362 | 4384.534 | 958 | 720 | 238 | 16.28 |
| 12 | 62.3108 | 4550.244 | ... | ... | ... | ... | 1 | 46.0199 | 4376.656 | ... | ... | ... | ... |
| 11 | 60.7739 | 4532.258 | 690 | 202 | 488 | 32.27 | 2 | 45.2045 | 4368.866 | 298 | 840 | 458 | 31.43 |
| 12 | 60.5228 | 4529.354 | ... | ... | ... | ... | 2 | 42.2765 | 4341.509 | 949 | 634 | 315 | 21.66 |
| 12 | 57.5196 | 4495.363 | ... | ... | ... | ... | 12 | 39.4279 | 4315.792 | ... | ... | ... | ... |
| 12 | 54.8062 | 4465.776 | 200 | 972 | 228 | 15.31 | 2 | 38.6559 | 4308.909 | 425 | 023 | 402 | 29.97 |
| 1 | 54.5412 | 4462.942 | 366 | 977 | 389 | 26.15 | 2 | 37.6232 | 4299.954 | ... | ... | ... | ... |
| 1 | 54.2551 | 4459.893 | ... | ... | ... | ... | 1 | 37.0706 | 4295.148 | 620 | 273 | 347 | 24.22 |
| 1 | 53.8852 | 4455.966 | 390 | 962 | 428 | 22.07 | 2 | 33.0446 | 4261.155 | ... | ... | ... | ... |
| 1 | 53.4774 | 4451.639 | 079 | 597 | 482 | 32.45 | 2 | 33.0766 | 4261.419 | 923 | 523 | 400 | 28.14 |
| 1 | 51.5374 | 4431.472 | 888 | 678 | 210 | 14.21 | 12 | 28.9090 | 4227.803 | 371 | 610 | 361 | 25.59 |
| 1 | 51.2451 | 4428.473 | 893 | 420 | 473 | 32.02 | 2 | 24.3115 | 4192.463 | 103 | 678 | 425 | +30.37 |
| 12 | 51.0727 | 4426.719 | 135 | 805 | 330 | 22.37 | 2 | 22.9365 | 4182.232 | ... | ... | ... | ... |
| 12 | 50.0457 | 4416.282 | 702 | 293 | 409 | 27.76 | | | | | | | |

Weighted mean..... +24.60
 V_a -25.76
 V_d -21
 Curvature..... -28

Radial velocity..... -1.7

 γ BOÖTIS 366.1906. Aug. 6.
G. M. T. 14^h 5^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 24 | 65.2314 | 4584.018 | ... | ... | ... | ... | 12 | 46.8746 | 4383.831 | 871 | 720 | 151 | 10.42 |
| 1 | 64.2565 | 4572.121 | ... | ... | ... | ... | 12 | 46.8483 | 4383.577 | ... | ... | ... | ... |
| 2 | 62.4060 | 4549.971 | 039 | 766 | 273 | +18.00 | 1 | 45.6093 | 4371.677 | 707 | 312 | 395 | 27.11 |
| 2 | 62.3706 | 4549.552 | ... | ... | ... | ... | 12 | 45.2419 | 4368.182 | 210 | 840 | 370 | 25.38 |
| 14 | 60.8339 | 4531.583 | 495 | 202 | 293 | 19.38 | 1 | 16.0709 | 4376.090 | ... | ... | ... | ... |
| 1 | 60.5846 | 4528.704 | ... | ... | ... | ... | 12 | 42.3186 | 4340.924 | 936 | 634 | 302 | 20.85 |
| 12 | 60.1077 | 4523.221 | 307 | 855 | 452 | 29.97 | 12 | 39.4696 | 4315.255 | ... | ... | ... | ... |
| 2 | 57.5747 | 4494.670 | ... | ... | ... | ... | 12 | 38.6818 | 4308.308 | 296 | 023 | 273 | 18.99 |
| 1 | 53.9251 | 4455.161 | 247 | 962 | 285 | 20.18 | 2 | 37.0702 | 4294.292 | ... | ... | ... | ... |
| 1 | 53.5350 | 4451.047 | 131 | 507 | 534 | 35.98 | 2 | 33.0764 | 4260.658 | ... | ... | ... | ... |
| 14 | 54.3107 | 4459.249 | ... | ... | ... | ... | 12 | 28.9585 | 4227.371 | 349 | 010 | 339 | 24.03 |
| 1 | 51.5845 | 4430.779 | 859 | 678 | 181 | 12.25 | 12 | 25.2344 | 4198.838 | 830 | 403 | 427 | 28.48 |
| 12 | 50.0835 | 4415.538 | 602 | 293 | 309 | 21.09 | 1 | 24.3315 | 4192.055 | 047 | 678 | 369 | +26.37 |
| 12 | 50.0371 | 4415.051 | ... | ... | ... | ... | 2 | 22.9657 | 4181.919 | ... | ... | ... | ... |
| 2 | 49.0520 | 4405.195 | 251 | 951 | 300 | 20.42 | | | | | | | |

Weighted mean..... +23.28
 V_a -23.23
 V_d -21
 Curvature..... -28

Radial velocity..... -0.4

9-10 EDWARD WIL. A. 1910

η BOÖTIS 572.

1906, Aug. 8.
G. M. T. 14^h 15^mObserved by } W. E. HARPER.
Measured by }

| Wt | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|----|-------------------------|-----------------------------|---------------------------|------------------------|------------------------------------|-----------|----|-------------------------|-----------------------------|---------------------------|------------------------|------------------------------------|-----------|
| 12 | 72 9730 | 1584 279 | | | | | 2 | 59 0301 | 4427 683 | 683 | 420 | 263 | 17 80 |
| 12 | 71 4967 | 4566 264 | 114 | 726 | 388 | +25 33 | 3 | 57 8275 | 4415 472 | 456 | 244 | 212 | 14 43 |
| 12 | 71 3535 | 4564 535 | | | | | 3 | 56 7962 | 4405 149 | 149 | 951 | 198 | 13 48 |
| 12 | 70 6887 | 4556 559 | 539 | 202 | 337 | 22 14 | 38 | 56 7738 | | | | | |
| 12 | 70 1445 | 4550 083 | 083 | 766 | 317 | 29 85 | 2 | 55 8252 | 4395 351 | 367 | 286 | 291 | 19 84 |
| 38 | 70 1072 | | | | | | 2 | 54 6369 | 4383 963 | 965 | 720 | 275 | 18 81 |
| 12 | 68 9701 | 4536 273 | 233 | 965 | 268 | 17 71 | 1 | 54 6080 | 4383 683 | | | | |
| 12 | 68 3516 | 4529 077 | 017 | 807 | 210 | 13 90 | 1 | 53 3464 | 4371 570 | 602 | 312 | 290 | 19 89 |
| 12 | 68 3336 | 4528 881 | | | | | 1 | 53 1912 | 4370 093 | 125 | 856 | 269 | 18 45 |
| 12 | 68 0462 | 4525 563 | 505 | 295 | 210 | 13 95 | 1 | 52 9897 | 4368 180 | 210 | 840 | 370 | 25 38 |
| 12 | 67 8440 | 4523 237 | 177 | 855 | 322 | 21 24 | 2 | 52 1188 | 4359 963 | 979 | 784 | 195 | 13 41 |
| 12 | 65 9487 | 4501 743 | 743 | 431 | 312 | 20 74 | 2 | 52 0196 | 4359 033 | 050 | 732 | 318 | 21 87 |
| 12 | 65 3170 | 4494 693 | | | | | 2 | 51 2852 | 4352 180 | 180 | 006 | 174 | 11 98 |
| 12 | 64 1450 | 4481 782 | 806 | 591 | 215 | 14 38 | 3 | 48 4145 | 4325 973 | | | | |
| 12 | 63 6316 | 4476 186 | | | | | 2 | 47 1450 | 4314 668 | 660 | 353 | 307 | 21 30 |
| 12 | 63 0377 | 4470 518 | 558 | 300 | 258 | 17 28 | 2 | 48 4512 | 4326 302 | 270 | 939 | 331 | 22 93 |
| 12 | 62 7485 | 4466 650 | | | | | 38 | 46 3963 | | | | | |
| 12 | 62 7757 | 4466 943 | 983 | 771 | 212 | 14 22 | 2 | 44 8470 | 4294 632 | 552 | 273 | 279 | 19 50 |
| 12 | 62 0833 | 4459 540 | 588 | 304 | 284 | 19 08 | 2 | 44 8210 | 4294 409 | | | | |
| 12 | 62 0545 | 4459 233 | | | | | 2 | 44 1405 | 4288 580 | 500 | 134 | 366 | 25 58 |
| 12 | 61 2637 | 4450 865 | 913 | 596 | 317 | 21 33 | 1 | 42 5767 | 4275 360 | 280 | 922 | 358 | 25 09 |
| 12 | 59 7795 | 4435 386 | 406 | 184 | 222 | 15 00 | | | | | | | |

Weighted mean +18 89

 V_a -22 83 V_d -28

Curvature -50

Radial velocity -4 7

SEASONAL PAPER No. 25a

 η BOÖTIS 657.1897. March 8.
G. M. T. 18^h 45^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 70.1436 | 4550.186 | ... | ... | ... | ... | 1 | 58.8587 | 4425.560 | 385 | 805 | 420 | 28.43 |
| 2 | 70.1197 | 4549.902 | 356 | 766 | 410 | -27.02 | 3 | 57.8397 | 4415.172 | 033 | 293 | 260 | 17.65 |
| 2 | 68.9542 | 4536.160 | 665 | 965 | 300 | 19.86 | 3 | 56.8292 | 4405.001 | ... | ... | ... | ... |
| 2 | 68.5475 | 4531.415 | 982 | 202 | 220 | 14.58 | 3 | 56.7587 | 4404.697 | 601 | 951 | 350 | 23.83 |
| 1½ | 68.4181 | 4529.911 | 489 | 849 | 360 | 23.86 | 3 | 55.8360 | 4395.127 | 056 | 286 | 230 | 16.00 |
| 2 | 68.3585 | 4529.219 | ... | ... | ... | ... | 3 | 54.6789 | 4383.776 | ... | ... | ... | ... |
| 2 | 68.3380 | 4528.981 | 357 | 807 | 250 | 16.57 | 2 | 54.6412 | 4383.409 | 370 | 720 | 350 | 23.94 |
| 2 | 67.8226 | 4523.022 | 625 | 855 | 230 | 15.25 | 2 | 53.3717 | 4371.145 | 152 | 312 | 160 | 10.96 |
| 2 | 65.3575 | 4495.078 | ... | ... | ... | ... | 2 | 53.2120 | 4369.615 | 636 | 856 | 220 | 15.07 |
| 2 | 65.3175 | 4494.631 | 270 | 550 | 280 | 18.67 | 2 | 51.3172 | 4351.693 | 786 | 006 | 220 | 15.14 |
| 1½ | 62.8652 | 4467.078 | ... | ... | ... | ... | 2 | 50.0839 | 4340.245 | 364 | 634 | 270 | 18.63 |
| 2 | 62.6047 | 4464.020 | 562 | 772 | 210 | 14.07 | 3 | 48.4987 | 4325.775 | ... | ... | ... | ... |
| 2 | 61.6695 | 4454.916 | 642 | 962 | 320 | 21.54 | 2 | 47.9197 | 4320.558 | 552 | 992 | 240 | 16.63 |
| 2 | 61.2555 | 4450.527 | 257 | 597 | 340 | 22.88 | 3 | 46.4945 | 4307.864 | ... | ... | ... | ... |
| 2 | 59.0292 | 4427.311 | 130 | 420 | 290 | 19.63 | 3 | 46.4645 | 4307.596 | 793 | 023 | 230 | -15.98 |

Weighted mean - 18.92

 V_a + 13.75 V_d + .00

Curvature - .50

Radial velocity - 5.6

 η BOÖTIS 670.1907. March 20
G. M. T. 18^h 32^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 72.9506 | 4583.964 | ... | ... | ... | ... | 3 | 56.7806 | 4404.929 | ... | ... | ... | ... |
| 2 | 71.9460 | 4571.690 | 762 | 112 | 350 | -22.92 | 3 | 56.7601 | 4404.724 | 721 | 951 | 230 | 15.68 |
| 1½ | 70.0986 | 4549.552 | ... | ... | ... | ... | 2 | 55.7993 | 4395.209 | ... | ... | ... | ... |
| 3 | 70.0827 | 4549.365 | 436 | 766 | 330 | 21.74 | 2 | 54.6290 | 4383.769 | ... | ... | ... | ... |
| 2 | 68.9205 | 4535.721 | 775 | 965 | 190 | 12.58 | 2 | 54.5986 | 4383.548 | 520 | 720 | 200 | 13.68 |
| 1 | 68.5150 | 4531.010 | 062 | 202 | 140 | 9.28 | 1 | 53.1621 | 4369.660 | 626 | 856 | 230 | 15.78 |
| 2 | 68.3215 | 4528.772 | ... | ... | ... | ... | 2 | 51.2715 | 4351.839 | 796 | 006 | 216 | 14.86 |
| 1 | 68.3066 | 4528.600 | 647 | 807 | 160 | 10.61 | 1 | 50.0474 | 4340.514 | 474 | 634 | 150 | 11.04 |
| 1 | 67.7947 | 4522.500 | 635 | 855 | 220 | 14.60 | 3 | 48.4494 | 4325.976 | ... | ... | ... | ... |
| 1 | 65.3175 | 4494.740 | ... | ... | ... | ... | 2 | 48.4195 | 4325.707 | 639 | 939 | 280 | 19.38 |
| 1 | 65.2786 | 4494.308 | 320 | 550 | 230 | 15.34 | 2 | 47.8720 | 4320.790 | 732 | 992 | 260 | 18.00 |
| 1 | 62.7505 | 4466.699 | 551 | 771 | 220 | 14.74 | 3 | 46.4482 | 4308.150 | ... | ... | ... | ... |
| 1 | 62.7368 | 4466.540 | 592 | 772 | 180 | 12.08 | 3 | 46.4205 | 4307.906 | 843 | 023 | 180 | 12.50 |
| 1½ | 62.5533 | 4464.583 | ... | ... | ... | ... | 1½ | 48.2000 | 4271.650 | 570 | 865 | 295 | 20.56 |
| 2 | 61.6272 | 4454.717 | 725 | 962 | 237 | 15.93 | 2 | 40.8897 | 4260.744 | ... | ... | ... | ... |
| 1 | 58.0902 | 4427.252 | 260 | 420 | 160 | 10.83 | 2 | 40.8547 | 4260.455 | 370 | 640 | 270 | -18.87 |
| 3 | 57.7921 | 4415.071 | 083 | 293 | 210 | 14.26 | ... | ... | ... | ... | ... | ... | ... |

Weighted mean - 15.25

 V_a + 8.78 V_d + .04

Curvature - .50

Radial velocity - 6.9

9-10 EDWARD VII., A. 1910

7 BOÖTIS 691.

1907. April 8.
G. M. T. 18^h 02^m.Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 12 | 72 9612 | 4584 046 | ..... | ..... | ..... | ..... | 3 | 56 7745 | 4404 984 | ..... | ..... | ..... | ..... |
| 1 | 71 9513 | 4571 717 | 730 | 900 | 170 | -11 13 | 3 | 56 7572 | 4404 812 | 761 | 951 | 190 | 13 62 |
| 1 | 70 6445 | 4556 013 | 622 | 202 | 180 | 11 80 | 3 | 55 7889 | 4395 232 | 176 | 286 | 110 | 7 50 |
| 3 | 70 0995 | 4549 546 | 556 | 766 | 210 | 13 84 | 12 | 54 6189 | 4383 808 | ..... | ..... | ..... | ..... |
| 12 | 70 1085 | 4549 612 | ..... | ..... | ..... | ..... | 12 | 54 5876 | 4383 504 | 440 | 720 | 280 | 19 83 |
| 1 | 68 9195 | 4535 705 | 695 | 965 | 270 | 17 87 | 1 | 53 3159 | 4371 275 | 202 | 312 | 110 | 7 55 |
| 1 | 68 5217 | 4531 088 | 072 | 202 | 130 | 8 62 | 1 | 53 1540 | 4369 732 | 666 | 856 | 190 | 13 03 |
| 12 | 68 3245 | 4528 809 | ..... | ..... | ..... | ..... | 2 | 51 2648 | 4351 942 | 876 | 006 | 130 | 8 96 |
| 1 | 67 7992 | 4522 765 | 735 | 855 | 120 | 7 96 | 12 | 50 0325 | 4340 553 | 489 | 634 | 145 | 10 00 |
| 1 | 65 3250 | 4494 834 | ..... | ..... | ..... | ..... | 12 | 48 4305 | 4325 995 | ..... | ..... | ..... | ..... |
| 1 | 65 2775 | 4494 329 | 270 | 550 | 280 | 18 67 | 1 | 47 8566 | 4320 846 | 792 | 992 | 200 | 13 88 |
| 1 | 63 3106 | 4472 793 | 737 | 957 | 220 | 14 76 | 12 | 47 2100 | 4315 086 | 638 | 178 | 140 | 9 73 |
| 2 | 62 7485 | 4466 737 | 612 | 772 | 160 | 10 74 | 3 | 46 4200 | 4308 108 | ..... | ..... | ..... | ..... |
| 1 | 62 5545 | 4464 657 | ..... | ..... | ..... | ..... | 12 | 46 4001 | 4307 932 | 883 | 023 | 140 | 9 74 |
| 1 | 62 0287 | 4459 047 | 004 | 304 | 300 | 20 16 | 12 | 40 8496 | 4260 662 | ..... | ..... | ..... | ..... |
| 2 | 61 6241 | 4454 755 | 712 | 962 | 250 | 16 80 | 1 | 40 8220 | 4256 434 | 420 | 640 | 220 | 15 48 |
| 2 | 61 2216 | 4450 507 | 467 | 597 | 130 | 8 79 | 1 | 37 8036 | 4235 956 | 962 | 112 | 150 | 10 62 |
| 2 | 58 9911 | 4427 357 | 320 | 420 | 100 | 6 77 | 1 | 37 0112 | 4229 664 | 676 | 826 | 150 | -10 65 |
| 1 | 58 8290 | 4425 039 | 605 | 805 | 200 | 13 54 | 1 | 36 7472 | 4227 580 | ..... | ..... | ..... | ..... |
| 3 | 57 7905 | 4415 163 | 113 | 293 | 180 | 12 22 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Weighted mean -12 29

 V_a + 2 59 V_d 00

Curvature..... 50

Radial velocity..... -10 2

7 BOÖTIS 731.

1907. April 19.
G. M. T. 18^h 35^m.Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 1 | 72 9712 | 4584 004 | ..... | ..... | ..... | ..... | 2 | 56 7843 | 4405 001 | 601 | 951 | 050 | + 3 40 |
| 1 | 71 9874 | 4571 996 | 106 | 116 | 010 | - 0 65 | 3 | 56 7769 | 4404 927 | ..... | ..... | ..... | ..... |
| 2 | 70 1315 | 4549 777 | 776 | 776 | 010 | + 0 66 | 1 | 55 8147 | 4395 409 | 386 | 286 | 100 | + 6 83 |
| 1 | 70 1200 | 4549 641 | ..... | ..... | ..... | ..... | 12 | 54 6220 | 4383 766 | ..... | ..... | ..... | ..... |
| 1 | 68 9540 | 4535 965 | 965 | 965 | 000 | 00 | 12 | 54 6211 | 4383 757 | 720 | 720 | 000 | 00 |
| 1 | 68 3433 | 4528 888 | 887 | 807 | 080 | + 5 28 | 12 | 53 1719 | 4369 837 | 806 | 856 | 050 | - 3 43 |
| 1 | 68 3355 | 4528 798 | ..... | ..... | ..... | ..... | 12 | 48 4312 | 4325 956 | ..... | ..... | ..... | ..... |
| 1 | 63 3442 | 4473 043 | 007 | 957 | 050 | + 3 35 | 1 | 48 4336 | 4325 977 | 959 | 939 | 020 | + 1 38 |
| 1 | 62 7670 | 4466 826 | ..... | ..... | ..... | ..... | 3 | 46 4205 | 4308 075 | ..... | ..... | ..... | ..... |
| 1 | 62 5922 | 4464 952 | 902 | 772 | 130 | + 8 74 | 12 | 46 4160 | 4308 036 | 033 | 023 | 010 | + 0 69 |
| 1 | 61 6492 | 4454 916 | 892 | 962 | 070 | - 4 72 | 12 | 40 8494 | 4260 646 | ..... | ..... | ..... | ..... |
| 1 | 58 8439 | 4425 761 | 755 | 805 | 050 | - 3 38 | 12 | 40 8433 | 4260 595 | 590 | 640 | 050 | - 3 50 |
| 2 | 57 8224 | 4415 399 | 393 | 293 | 100 | + 6 80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Weighted mean + 1 34

 V_a + 4 57 V_d 11

Curvature..... 50

Radial velocity..... - 3 8

SESSIONAL PAPER No. 25a

♄ BOÖTIS 739.

1907. April 26.
G. M. T. 17^h 30^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 3 | 70 0827 | 4549 755 | 796 | 766 | 030 | + 1 98 | 3 | 57 7755 | 4415 358 | 373 | 293 | 080 | + 5 43 |
| 12 | 70 0639 | 4549 604 | .. | .. | .. | .. | 3 | 56 7328 | 4404 911 | .. | .. | .. | .. |
| 12 | 68 9152 | 4536 057 | 105 | 965 | 040 | + 2 65 | 3 | 56 7360 | 4404 943 | 961 | 951 | 010 | + 0 68 |
| 1 | 68 4980 | 4531 213 | 252 | 202 | 050 | + 3 31 | 12 | 55 7610 | 4395 296 | 326 | 286 | 040 | + 2 73 |
| 2 | 68 2387 | 4528 736 | .. | .. | .. | .. | 12 | 54 5687 | 4383 616 | .. | .. | .. | .. |
| 1 | 67 7681 | 4522 804 | 845 | 855 | 010 | - 0 66 | 12 | 54 5705 | 4383 670 | 750 | 720 | 030 | + 2 05 |
| 1 | 65 8880 | 4501 514 | 548 | 508 | 040 | + 2 66 | 1 | 53 1335 | 4369 862 | 926 | 856 | 070 | + 4 30 |
| 2 | 65 2791 | 4494 730 | .. | .. | .. | .. | 12 | 51 2440 | 4352 056 | 126 | 006 | 120 | + 8 26 |
| 1 | 65 2655 | 4494 580 | 620 | 550 | 070 | + 4 66 | 12 | 50 0165 | 4340 719 | 774 | 634 | 140 | + 9 66 |
| 1 | 63 6012 | 4476 313 | 334 | 214 | 120 | + 8 04 | 12 | 48 3872 | 4325 910 | .. | .. | .. | .. |
| 12 | 63 5860 | 4476 149 | .. | .. | .. | .. | 12 | 48 3885 | 4325 922 | 969 | 939 | 030 | + 2 07 |
| 1 | 63 2975 | 4473 023 | 037 | 957 | 080 | + 5 37 | 1 | 47 8422 | 4321 020 | 042 | 992 | 050 | + 3 46 |
| 2 | 62 7133 | 4466 729 | .. | .. | .. | .. | 3 | 46 3798 | 4308 051 | .. | .. | .. | .. |
| 22 | 61 6094 | 4454 963 | 972 | 962 | 010 | + 0 67 | 4 | 46 3895 | 4308 110 | 133 | 023 | 110 | + 7 63 |
| 2 | 61 2057 | 4450 702 | 707 | 597 | 110 | + 7 41 | 2 | 40 8133 | 4260 641 | .. | .. | .. | .. |
| 12 | 58 9633 | 4427 425 | 430 | 420 | 010 | + 0 67 | 2 | 40 8102 | 4260 612 | 610 | 640 | 031 | - 2 11 |

Weighted mean..... + 3 70

V_a..... - 7 58V_d..... - 09

Curvature..... - 50

Radial velocity..... - 4 5

♄ BOÖTIS 752.

1907. May 7.
G. M. T. 14^h 20^mObserved by }
Measured by } W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 1 | 73 0097 | 4584 671 | .. | .. | .. | .. | 1 | 61 2811 | 4450 747 | 807 | 597 | 210 | 14 13 |
| 12 | 72 0492 | 4572 350 | 392 | 112 | 280 | + 18 31 | 12 | 59 0410 | 4427 514 | 570 | 420 | 150 | 10 15 |
| 12 | 70 1677 | 4549 830 | 866 | 776 | 100 | 6 60 | 3 | 57 8548 | 4415 473 | 533 | 293 | 240 | 16 30 |
| 1 | 70 1520 | 4549 640 | .. | .. | .. | .. | 3 | 56 8036 | 4404 951 | 021 | 951 | 070 | 4 77 |
| 2 | 69 0077 | 4536 228 | 286 | 965 | 320 | 21 18 | 3 | 56 7947 | 4404 863 | .. | .. | .. | .. |
| 12 | 68 5945 | 4531 433 | 492 | 202 | 290 | 19 20 | 2 | 55 8355 | 4395 880 | 456 | 286 | 170 | 11 62 |
| 3 | 68 3596 | 4528 720 | .. | .. | .. | .. | 2 | 54 6312 | 4383 633 | 720 | 720 | 000 | 00 |
| 1 | 68 3767 | 4528 917 | 987 | 807 | 180 | 11 92 | 2 | 54 6284 | 4383 606 | .. | .. | .. | .. |
| 12 | 67 8737 | 4523 121 | 195 | 855 | 340 | 22 54 | 3 | 53 2125 | 4370 014 | 116 | 856 | 260 | 17 84 |
| 1 | 65 7679 | 4489 332 | 399 | 129 | 270 | 17 98 | 1 | 51 3040 | 4352 057 | 166 | 006 | 160 | 11 00 |
| 1 | 65 3486 | 4494 672 | .. | .. | .. | .. | 1 | 50 0865 | 4340 815 | 934 | 634 | 300 | 20 70 |
| 1 | 65 3460 | 4494 679 | 750 | 550 | 200 | 13 34 | 3 | 48 4356 | 4325 827 | .. | .. | .. | .. |
| 12 | 63 3679 | 4472 994 | 057 | 957 | 100 | 6 70 | 12 | 47 8955 | 4320 987 | 122 | 992 | 130 | 9 00 |
| 1 | 62 7800 | 4466 663 | .. | .. | .. | .. | 3 | 46 4197 | 4307 917 | .. | .. | .. | .. |
| 1 | 62 6280 | 4465 038 | 102 | 772 | 330 | 22 11 | 12 | 46 4370 | 4308 068 | 223 | 023 | 200 | + 13 88 |
| 2 | 61 6967 | 4455 067 | 132 | 962 | 170 | 11 44 | 2 | 40 8503 | .. | .. | .. | .. | .. |

Weighted mean..... + 13 07

V_a..... - 12 01V_d..... + 11

Curvature..... - 50

Radial velocity..... + 0 7

9-10 EDWARD VII., A. 1910

η BOÖTIS 760.

1907. May 14.
G. M. T. 17^h 35^mObserved by }
Measured by } W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 77.0138 | 4586.749 | ... | ... | ... | ... | 1½ | 60.3522 | 4476.077 | ... | ... | ... | ... |
| 1½ | 75.0110 | 4572.563 | 402 | 112 | 290 | -18.96 | 1 | 60.3978 | 4476.358 | 438 | 214 | 224 | 14.03 |
| 1 | 74.0961 | 4566.168 | 006 | 726 | 280 | 18.30 | ½ | 59.8743 | 4473.133 | 223 | 957 | 266 | 17.84 |
| 1 | 72.7052 | 4556.546 | 426 | 202 | 224 | 14.72 | 1½ | 51.9075 | 4425.754 | 924 | 608 | 316 | 21.39 |
| 1½ | 71.7530 | 4550.028 | 906 | 766 | 140 | 9.22 | 1 | 48.7471 | 4407.805 | 995 | 851 | 144 | 9.80 |
| 1 | 71.7146 | 4549.767 | ... | ... | ... | ... | 3 | 48.1928 | 4404.704 | ... | ... | ... | ... |
| 2 | 68.5907 | 4528.772 | ... | ... | ... | ... | 1 | 42.9610 | 4371.304 | 632 | 312 | 320 | +21.95 |
| 1½ | 68.0928 | 4525.481 | 441 | 295 | 146 | 9.66 | 1½ | 38.5042 | 4352.659 | ... | ... | ... | ... |
| 1½ | 67.7272 | 4523.072 | 035 | 855 | 180 | 11.92 | | | | | | | |

Weighted mean +15.25

V_a -14.70V_d -14

Curvature -50

Radial velocity -0.1

π BOÖTIS 764.

1907. May 20.
G. M. T. 16^h 25^mObserved by }
Measured by } W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 76.8697 | 4586.673 | 521 | 191 | 330 | +21.52 | 1 | 57.5027 | 4459.583 | 604 | 304 | 300 | 20.22 |
| 1½ | 76.8647 | 4586.638 | 208 | 018 | 190 | 12.39 | 1 | 56.0698 | 4450.947 | 967 | 597 | 370 | 24.93 |
| 1 | 76.5408 | 4584.329 | 018 | 618 | 400 | 26.03 | 2 | 53.4276 | 4435.427 | 444 | 184 | 260 | 17.57 |
| 1 | 76.2327 | 4582.137 | ... | ... | ... | ... | 2 | 52.0857 | 4427.650 | 666 | 420 | 246 | 16.65 |
| 2 | 76.0206 | 4580.696 | ... | ... | ... | ... | 1½ | 51.8037 | 4426.026 | 038 | 608 | 430 | 29.11 |
| 1 | 73.6800 | 4564.218 | 149 | 939 | 210 | 13.75 | 2½ | 49.9630 | 4415.519 | 523 | 293 | 230 | 15.62 |
| 1½ | 72.5669 | 4556.532 | 472 | 202 | 270 | 17.76 | 2 | 49.9173 | 4415.260 | ... | ... | ... | ... |
| 1 | 72.2842 | 4554.592 | 537 | 257 | 280 | 18.42 | 2 | 48.1222 | 4405.163 | 171 | 951 | 220 | 15.60 |
| 1 | 72.0388 | 4552.913 | 864 | 594 | 270 | 17.76 | 2 | 46.3847 | 4395.539 | 539 | 286 | 253 | 17.25 |
| 2½ | 71.6337 | 4550.080 | 046 | 766 | 280 | 18.42 | 1½ | 44.2712 | 4384.005 | 005 | 720 | 285 | 20.14 |
| 1 | 71.5812 | 4549.791 | ... | ... | ... | ... | 2 | 43.4159 | 4379.392 | ... | ... | ... | ... |
| 1 | 69.5846 | 4536.314 | 295 | 965 | 330 | 21.81 | 1½ | 41.9670 | 4371.648 | 652 | 312 | 340 | 23.30 |
| 2 | 68.4979 | 4529.079 | 077 | 807 | 270 | 17.87 | 2 | 39.7680 | 4360.064 | 074 | 784 | 290 | 19.90 |
| 2 | 67.5900 | 4522.147 | 155 | 855 | 300 | 19.89 | 1½ | 39.5791 | 4359.078 | 086 | 732 | 354 | 24.28 |
| 2 | 65.3760 | 4508.673 | 685 | 455 | 230 | 15.30 | 1 | 38.4112 | 4353.015 | ... | ... | ... | ... |
| 1½ | 64.3050 | 4501.799 | 818 | 448 | 370 | 24.64 | 2 | 38.2760 | 4352.317 | 336 | 006 | 330 | 22.70 |
| 2 | 63.2326 | 4494.979 | 994 | 664 | 330 | 22.01 | 2 | 36.0640 | 4340.994 | 004 | 634 | 370 | 25.53 |
| 1 | 63.1922 | 4494.724 | ... | ... | ... | ... | 2 | 33.0691 | 4325.962 | ... | ... | ... | ... |
| 1½ | 61.1145 | 4481.603 | 710 | 400 | 310 | 20.74 | 1½ | 33.1252 | 4326.247 | 239 | 939 | 300 | 20.76 |
| 2 | 60.2770 | 4476.506 | 524 | 214 | 310 | 20.74 | 2 | 32.1120 | 4321.238 | 226 | 992 | 234 | 16.20 |
| 1½ | 59.7526 | 4473.277 | 297 | 957 | 340 | 22.78 | 1½ | 30.9560 | 4315.473 | 458 | 178 | 280 | 19.40 |
| 1 | 59.1947 | 4469.856 | 876 | 520 | 356 | 23.85 | 2 | 29.4608 | 4308.313 | 293 | 023 | 270 | 18.72 |
| 1 | 58.6782 | 4466.704 | ... | ... | ... | ... | 2 | 29.4193 | 4308.113 | ... | ... | ... | ... |
| 1 | 58.4203 | 4465.137 | 162 | 772 | 390 | 26.13 | 2 | 25.2745 | 4288.450 | 424 | 134 | 290 | +20.27 |

Weighted mean +20.26

V_a -16.77V_d -10

Curvature -50

Radial velocity +2.91

SESSIONAL PAPER No. 25a

 η BOOTIS 769.1907, May 22.
G. M. T. 16^h 51^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 72 37.51 | 4554.627 | .597 | .597 | .250 | 16.47 | 2 | 57.5897 | 4459.591 | .644 | .304 | .310 | 22.91 |
| 1 $\frac{1}{2}$ | 72 14.97 | 4553.084 | .964 | .594 | .370 | 24.38 | 1 | 56.8922 | 4455.219 | .272 | .962 | .310 | 20.89 |
| 3 | 71 71.56 | 4550.122 | .006 | .766 | .240 | 16.00 | 1 $\frac{1}{2}$ | 52.1741 | 4427.666 | .720 | .420 | .390 | 20.31 |
| 1 $\frac{1}{2}$ | 71 06.51 | 4549.777 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 50.0535 | 4415.548 | .598 | .298 | .305 | 20.70 |
| 2 | 68 67.39 | 4536.338 | .255 | .965 | .290 | 19.20 | 1 $\frac{1}{2}$ | 49.9998 | 4415.244 | ..... | ..... | ..... | ..... |
| 2 | 68 59.89 | 4529.180 | .107 | .807 | .300 | 19.86 | 1 $\frac{1}{2}$ | 48.2070 | 4405.164 | .211 | .951 | .260 | 17.73 |
| 2 | 68 54.77 | 4528.841 | ..... | ..... | ..... | ..... | 2 | 48.1555 | 4404.877 | ..... | ..... | ..... | ..... |
| 2 | 67 68.70 | 4523.161 | .105 | .855 | .250 | 16.55 | 3 | 43.4978 | 4379.372 | ..... | ..... | ..... | ..... |
| 1 | 66 50.26 | 4515.805 | .768 | .598 | .260 | 17.10 | 1 $\frac{1}{2}$ | 42.0517 | 4371.654 | .702 | .312 | .390 | 26.75 |
| 1 | 66 40.65 | 4514.789 | .736 | .476 | .230 | 17.26 | 1 | 41.7560 | 4370.074 | .116 | .856 | .260 | 17.85 |
| 2 | 63 30.54 | 4494.898 | .894 | .664 | .230 | 15.34 | 1 | 41.3860 | 4368.116 | .160 | .840 | .320 | 21.95 |
| 1 $\frac{1}{2}$ | 63 28.38 | 4494.762 | ..... | ..... | ..... | ..... | 2 | 38.4841 | 4352.949 | ..... | ..... | ..... | ..... |
| 1 | 60 35.30 | 4476.447 | .481 | .214 | .270 | 18.09 | 1 $\frac{1}{2}$ | 38.3357 | 4352.182 | .246 | .666 | .240 | 16.54 |
| 2 | 59 84.26 | 4473.304 | .337 | .957 | .380 | 25.46 | 1 | 32.1922 | 4321.209 | .292 | .902 | .390 | 20.76 |
| 1 $\frac{1}{2}$ | 59 27.33 | 4469.814 | ..... | ..... | ..... | ..... | 2 | 30.9890 | 4315.312 | .408 | .178 | .230 | 15.92 |
| 2 | 58 48.74 | 4465.024 | .062 | .772 | .290 | 19.48 | 2 | 30.9643 | 4315.192 | ..... | ..... | ..... | ..... |

Weighted mean +19.46
 V_a -17.43
 V_d 14
 Curvature50

Radial velocity + 1.4

 η BOOTIS 774.1907, May 23.
G. M. T. 14^h 08^mObserved by W. E. HARPER.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 1 | 73 37.22 | 4871.511 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 42.5701 | 4299.750 | .726 | .277 | .247 | 17.23 |
| 1 $\frac{1}{2}$ | 73 53.07 | 4875.673 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 40.6425 | 4272.077 | .653 | .760 | .293 | 20.56 |
| 1 $\frac{1}{2}$ | 72 94.89 | 4861.911 | .803 | .527 | .276 | +17.03 | 1 $\frac{1}{2}$ | 40.4252 | 4269.004 | ..... | ..... | ..... | ..... |
| 1 | 56 7.339 | 4528.932 | ..... | ..... | ..... | ..... | 3 | 39.8399 | 4260.771 | .747 | .640 | .107 | 7.53 |
| 1 | 57 90.13 | 4549.900 | ..... | ..... | ..... | ..... | 2 | 36.5802 | 4216.114 | .102 | .897 | .105 | 7.47 |
| 1 | 57 92.93 | 4550.311 | .119 | .766 | .353 | 23.26 | 2 $\frac{1}{2}$ | 36.1574 | 4210.469 | ..... | ..... | ..... | ..... |
| 1 | 52 53.04 | 4455.601 | .565 | .962 | .603 | 40.65 | 1 $\frac{1}{2}$ | 35.5747 | 4202.733 | .733 | .161 | .272 | 17.51 |
| 2 $\frac{1}{2}$ | 48 85.21 | 4395.386 | ..... | ..... | ..... | ..... | 1 | 35.2917 | 4198.999 | .990 | .494 | .505 | 36.07 |
| 2 $\frac{1}{2}$ | 49 17.26 | 4400.502 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 33.5535 | 4202.202 | ..... | ..... | ..... | ..... |
| 1 | 49 45.86 | 4405.090 | .982 | .908 | .074 | 5.04 | 1 | 30.0803 | 4132.687 | .767 | .212 | .555 | 40.29 |
| 1 | 49 21.38 | 4401.162 | .162 | .138 | .424 | 28.87 | 1 | 29.3427 | 4123.660 | ..... | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 45 36.18 | 4341.187 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 28.9702 | 4119.134 | .234 | .844 | .390 | 28.38 |
| 1 | 45 34.71 | 4340.964 | .948 | .634 | .314 | 21.82 | 1 | 27.5532 | 4102.114 | .218 | .000 | .218 | 15.94 |
| 1 | 43 13.30 | 4307.974 | .950 | .932 | .018 | 1.25 | 2 | 26.7817 | 4092.974 | .078 | .626 | .452 | 33.13 |
| 2 | 42 55.31 | 4299.503 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Weighted mean +21.29
 V_a -17.73
 V_d 08
 Curvature28

Radial velocity + 3.2

9-10 EDWARD VII., A. 1910

 η BOÖTIS 779.1907. May 24.
G. M. T. 15^h 01^mObserved by J. S. PLASKETT.
Measured by J. N. TRIBBLE.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 58 0640 | 4543.549 | | | | | 1 $\frac{1}{2}$ | 40.8102 | 4271.728 | 872 | 760 | 112 | 7.85 |
| 1 | 58 0817 | 4549.873 | 001 | 766 | 235 | +15.46 | 2 | 37.6150 | 4227.429 | | | | |
| 2 | 50 2577 | 4415.039 | | | | | 1 $\frac{1}{2}$ | 37.5998 | 4227.211 | 331 | 904 | 427 | 30.27 |
| 1 | 50 2836 | 4415.459 | 595 | 293 | 302 | 20.54 | 1 | 36.7625 | 4215.917 | 021 | 897 | 124 | 8.82 |
| 2 | 49 6247 | 4404.812 | | | | | 1 | 35.4747 | 4198.795 | 907 | 403 | 505 | 35.99 |
| 1 | 49 6384 | 4405.032 | 216 | 951 | 265 | 18.05 | 1 | 33.0716 | 4167.618 | 706 | 438 | 268 | 19.27 |
| 1 | 46 3206 | 4352.943 | | | | | 2 | 31.1734 | 4143.682 | | | | |
| 1 | 46 2767 | 4352.270 | 454 | 006 | 448 | 30.86 | 1 | 31.1972 | 4143.979 | 051 | 914 | 137 | 9.91 |
| 1 | 45 5212 | 4340.763 | 939 | 634 | 305 | 20.95 | 1 | 29.9036 | 4127.997 | 063 | 862 | 191 | +13.88 |
| 2 | 40 8015 | 4271.605 | | | | | 2 | 28.0030 | 4104.992 | | | | |

Weighted mean. -18.15
 V_a -18.04
 V_d -21
Curvature. -28
Radial velocity. -0.3

 η BOÖTIS 793.1907. May 29.
G. M. T. 16^h 46^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 1 | 61 2267 | 4613.852 | | | | | 2 | 47.7600 | 4379.416 | | | | |
| 2 | 61 2151 | 4613.629 | 755 | 405 | 290 | +18.76 | 1 $\frac{1}{2}$ | 47.0501 | 4368.323 | 307 | 840 | 467 | 32.04 |
| 2 | 60 7801 | 4605.266 | 437 | 997 | 440 | 28.51 | 1 | 45.2664 | 4340.948 | 954 | 634 | 320 | 22.08 |
| 2 | 60 5522 | 4600.908 | 076 | 524 | 552 | 35.76 | 2 | 44.2835 | 4326.157 | 174 | 694 | 480 | 33.22 |
| 2 | 50 7843 | 4586.340 | | | | | 1 | 43.0657 | 4308.409 | 443 | 023 | 420 | 29.15 |
| 1 | 59 6576 | 4583.954 | 150 | 796 | 354 | 23.08 | 2 | 43.0009 | 4308.044 | | | | |
| 2 | 57 8364 | 4550.173 | 308 | 766 | 542 | 35.72 | 1 $\frac{1}{2}$ | 40.5687 | 4272.055 | 090 | 760 | 330 | 23.20 |
| 2 | 56 6522 | 4528.720 | | | | | 2 | 39.7598 | 4260.611 | | | | |
| 2 | 52 7172 | 4460.183 | | | | | 2 | 39.7727 | 4260.835 | 861 | 546 | 315 | 22.14 |
| 2 | 50 0340 | 4415.682 | 783 | 293 | 490 | 33.37 | 1 | 37.8163 | 4233.751 | 768 | 328 | 440 | 31.15 |
| 2 | 49 3867 | 4405.432 | 471 | 951 | 520 | 35.46 | 1 $\frac{1}{2}$ | 36.5183 | 4216.158 | 167 | 897 | 270 | +19.17 |
| 3 | 48 7702 | 4395.400 | | | | | 2 | 35.4705 | 4202.202 | | | | |
| 2 | 48 8021 | 4395.909 | 896 | 286 | 610 | 41.66 | | | | | | | |

Weighted mean. +29.03
 V_a -19.56
 V_d -15
Curvature -50
Radial velocity. +8.8

SESSIONAL PAPER No. 25a

1907. May 31.
G. M. T. 14^h 54^m η BOÖTIS 797.Observed by J. S. PLASKETT.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9660 | | | | 2 | 43.0819 | .0711 | .0208 | 21.20 |
| 2 | 72.8399 | .8829 | .0181 | +26.26 | 2 | 40.5728 | .5560 | .0301 | 29.86 |
| 2 | 72.4047 | | | | 2 | 39.7707 | .7517 | .0249 | 24.50 |
| 2 | 57.8365 | .8410 | .0142 | 17.10 | 2 | 39.7551 | | | |
| 2 | 57.8055 | | | | 1½ | 37.3501 | .3227 | .0339 | 32.51 |
| 2 | 50.0029 | | | | 2 | 36.5196 | .4893 | .0271 | 25.77 |
| 1½ | 49.3909 | .3937 | .0263 | 28.72 | 1½ | 35.4969 | .4631 | .0355 | 33.40 |
| 1 | 48.7877 | .7855 | .0215 | 23.53 | 2 | 35.4641 | | | |
| 2 | 48.7722 | | | | 1½ | 31.6032 | .5560 | .0151 | 13.65 |
| 1 | 47.0514 | .0483 | .0352 | 37.45 | 2 | 30.1736 | | | |
| 2 | 45.2777 | | | | 2 | 27.3086 | | | |
| 1½ | 45.2658 | .2617 | .0230 | 23.56 | 1½ | 26.7220 | .6579 | .0296 | +25.48 |
| 2 | 43.5481 | | | | 2 | 26.7084 | | | |

Weighted mean +25.50

 V_a -29.10 V_d -.05

Curvature -.28

Radial velocity + 5.1

 η BOÖTIS 812.1907. June 10.
G. M. T. 14^h 10^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|---------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|---------------|-----------|
| 2 | 72.8854 | 4864.874 | | | | | 2 | 43.0742 | 4308.544 | .560 | .023 | .537 | 37.37 |
| 2 | 72.7643 | 4862.010 | .047 | .527 | .520 | +32.08 | 2 | 42.0980 | 4294.278 | | | | |
| 1½ | 57.8020 | 4550.549 | .386 | .766 | .620 | 40.85 | 1 | 41.3355 | 4283.269 | .285 | .722 | .563 | 39.00 |
| 2 | 57.7617 | 4549.811 | | | | | 2 | 40.5595 | 4272.188 | .204 | .760 | .444 | 31.12 |
| 2 | 53.0646 | 4466.768 | | | | | 1½ | 39.7652 | 4260.968 | .987 | .527 | .460 | 32.34 |
| 2 | 52.9887 | 4465.474 | .412 | .772 | .640 | 42.94 | 2 | 39.7401 | 4260.615 | | | | |
| 2 | 52.4071 | 4455.617 | .562 | .962 | .600 | 40.32 | 2 | 39.0561 | 4251.055 | .067 | .643 | .424 | 29.89 |
| 2 | 52.2073 | 4452.249 | | | | | 1½ | 37.8028 | 4233.770 | .778 | .462 | .316 | 22.37 |
| 2 | 49.3623 | 4405.394 | .391 | .908 | .483 | 32.84 | 2 | 37.3322 | 4227.356 | .364 | .010 | .354 | 25.06 |
| 2 | 48.7661 | 4395.825 | .826 | .426 | .400 | 27.28 | 2 | 35.2093 | 4198.927 | .924 | .494 | .430 | 30.70 |
| 2 | 45.9963 | 4352.404 | .412 | .957 | .455 | 31.44 | 2 | 34.6878 | 4192.067 | .068 | .678 | .390 | 27.70 |
| 2 | 45.2575 | 4341.177 | | | | | 2 | 31.9631 | 4156.989 | .989 | .623 | .366 | 26.35 |
| 2 | 45.2518 | 4341.089 | .099 | .634 | .465 | 32.08 | 2 | 30.9498 | 4144.262 | .262 | .928 | .334 | +24.11 |
| 1½ | 44.2697 | 4326.286 | .299 | .939 | .360 | 24.91 | 2 | 27.3112 | 4099.919 | | | | |

Weighted mean +30.09

 V_a -22.52 V_d -.04

Curvature -.28

Radial velocity + 7.2

9-10 EDWARD VII., A. 1910

 η BOÖTIS 868.1907, June 21
G. M. T. 14^h 27^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|---------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|---------------|-----------|
| 3 | 59.4917 | 4580.498 | | | | | 12 | 45.2755 | 4341.084 | | | | |
| 12 | 59.0511 | 4572.262 | .308 | .758 | .550 | +35.91 | 12 | 44.2785 | 4326.119 | .199 | .939 | .260 | 18.00 |
| 3 | 57.8496 | 4550.094 | .156 | .766 | .390 | 25.70 | 12 | 43.5520 | 4315.347 | .448 | .178 | .270 | 18.71 |
| 12 | 57.8233 | 4549.613 | | | | | 12 | 42.1004 | 4294.152 | | | | |
| 3 | 56.6631 | 4528.612 | | | | | 1 | 40.5592 | 4272.120 | .270 | .760 | .510 | 35.70 |
| 12 | 56.3594 | 4523.178 | .345 | .985 | .360 | 23.80 | 12 | 39.7555 | 4260.816 | .947 | .527 | .420 | 29.53 |
| 12 | 53.1004 | 4466.545 | | | | | 12 | 39.7351 | 4260.530 | | | | |
| 12 | 50.9767 | 4430.966 | .138 | .678 | .460 | 31.14 | 1 | 36.4997 | 4216.283 | .323 | .897 | .426 | 30.12 |
| 12 | 50.0392 | 4415.661 | .824 | .354 | .470 | 31.96 | 12 | 35.4821 | 4202.761 | .768 | .198 | .570 | 40.58 |
| 12 | 50.0050 | 4415.107 | | | | | 12 | 35.4386 | 4202.190 | | | | |
| 12 | 49.4000 | 4405.349 | .498 | .908 | .590 | 40.18 | 1 | 34.6655 | 4192.048 | .038 | .678 | .360 | 25.74 |
| 12 | 48.7697 | 4395.275 | | | | | 1 | 32.7961 | 4167.952 | .902 | .617 | .285 | 20.49 |
| 12 | 47.2771 | 4371.789 | .893 | .343 | .550 | 37.62 | 12 | 30.1393 | 4134.712 | | | | |
| 12 | 47.1802 | 4370.281 | .387 | .867 | .620 | 35.56 | 1 | 29.9750 | 4132.694 | .592 | .212 | .380 | +27.40 |

Weighted mean..... +29.89

 V_a -24.46 V_d -11

Curvature..... -28

Radial velocity..... +5.0

 η BOÖTIS 891.1907, June 27.
G. M. T. 14^h 55^mObserved by W. E. HARPER.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 57.7980 | .8200 | .0173 | +20.87 | 2 | 40.5817 | .5833 | .0324 | 32.24 |
| 1 | 57.7762 | | | | 2 | 39.7320 | .7845 | .0300 | 29.61 |
| 2 | 49.9624 | | | | 2 | 39.7102 | | | |
| 1 | 49.3500 | .3936 | .0279 | 30.55 | 1 | 37.3062 | .3613 | .0363 | 35.57 |
| 2 | 48.7547 | .7987 | .0160 | 17.41 | 1 | 36.4711 | .5275 | .0262 | 25.41 |
| 2 | 48.7277 | | | | 1 | 35.4539 | .5119 | .0414 | 39.54 |
| 12 | 47.0142 | .0602 | .0391 | 41.25 | 2 | 35.4170 | | | |
| 2 | 45.2395 | | | | 1 | 31.5636 | .6300 | .0313 | 28.17 |
| 12 | 45.2330 | .2800 | .0322 | 33.71 | 2 | 30.1178 | | | |
| 2 | 43.5028 | | | | 2 | 27.2449 | | | |
| 2 | 43.0515 | .1009 | .0377 | 38.52 | 12 | 26.6395 | .7335 | .0272 | -24.13 |
| 2 | 42.0723 | | | | 2 | 26.6400 | | | |

Weighted mean..... +30.53

 V_a 24.37 V_d 17

Curvature..... -28

Radial velocity..... +5.7

SESSIONAL PAPER No. 25a

1907. July 8.
G. M. T. 15^h 09^m η BOÖTIS 913.Observed by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59.8099 | | | | 1 | 44.2898 | .2798 | .0206 | 21.27 |
| 1 | 57.8572 | .8620 | .0332 | -42.38 | 1 | 43.5460 | | | |
| 1 | 56.6611 | | | | 1 | 43.0888 | .0758 | .0255 | 25.98 |
| 1 | 55.1526 | 1576 | .0324 | 37.77 | 1 | 41.3060 | | | |
| 1½ | 54.7393 | | | | 1 | 40.5805 | .5615 | .0356 | 35.31 |
| 1 | 50.0034 | | | | 1 | 39.7823 | .7613 | .0264 | 25.97 |
| 1 | 50.0396 | .0296 | .0265 | 22.55 | 1 | 37.9860 | | | |
| 1 | 49.4064 | .4034 | .0300 | 39.31 | 1 | 37.3568 | .3308 | .0180 | 46.04 |
| 1 | 49.1127 | | | | 1½ | 36.5317 | .5047 | .0455 | 40.41 |
| 1 | 48.8040 | .8020 | .0292 | 31.68 | 1 | 35.4581 | | | |
| 1½ | 48.7675 | | | | 1 | 35.2228 | .1928 | .0438 | 41.08 |
| 1 | 46.0327 | .0257 | .0385 | 40.40 | 1 | 31.8048 | .7713 | .0232 | +21.01 |
| 1 | 45.2824 | .2744 | .0437 | 45.62 | 1 | 30.9164 | | | |
| 1 | 45.2825 | | | | | | | | |

Weighted mean..... +34.45

 V_a -25.79 V_d -24

Curvature..... -28

Radial velocity..... + 8.1

 η BOÖTIS 918.*1907. July 8.
G. M. T. 15^h 06^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1½ | 59.0510 | | | | 2 | 44.3211 | .2820 | .0228 | 23.55 |
| 1 | 59.0784 | .0634 | .0227 | -27.74 | 2 | 43.6749 | | | |
| 2 | 57.8689 | .8520 | .0252 | 30.34 | 2 | 43.1211 | .0790 | .0327 | 53.32 |
| 2 | 57.8388 | | | | 2 | 41.8827 | .8380 | | |
| 1 | 56.8542 | .8352 | .0244 | 29.04 | 2 | 41.3385 | | | |
| 2 | 56.6862 | | | | 2 | 40.6063 | .5590 | .0331 | 32.83 |
| 1 | 55.1704 | .1464 | .0212 | 24.72 | 2 | 39.8204 | .1694 | .0345 | 33.95 |
| 2 | 54.0562 | | | | 1½ | 39.7879 | | | |
| 1½ | 52.8790 | .8510 | .0206 | 23.40 | 2 | 39.1058 | .0553 | .0370 | 36.11 |
| 2 | 52.4827 | .4547 | .0399 | 45.13 | 2 | 38.0112 | | | |
| 2 | 52.2770 | | | | 2 | 37.3845 | .3295 | .0407 | 39.03 |
| 2 | 50.0586 | .0280 | .0179 | 19.69 | 2 | 36.5511 | .4940 | .0318 | 30.24 |
| 2 | 49.4332 | .4012 | .0350 | 38.22 | 2 | 35.4884 | | | |
| 2 | 48.8006 | | | | 1 | 35.5290 | .4706 | .0430 | 40.46 |
| 2 | 45.3140 | | | | 1½ | 35.2561 | .1973 | .0483 | +45.06 |
| 2 | 45.3180 | .2800 | .0413 | 43.12 | | | | | |

Weighted mean..... +33.11

 V_a -25.80 V_d -24

Curvature..... -28

Radial velocity..... + 6.8

*Check measurement.

9-10 EDWARD VII., A. 1910

 η BOÖTIS 950.1907, July 18.
G. M. T. 13^h 57^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 59.7949 | | | | 1½ | 43.5484 | .5524 | .0192 | 19.68 |
| 1 | 59.0652 | .0672 | .0265 | +32.36 | 2 | 43.0820 | .0852 | .0451 | 45.95 |
| 1½ | 57.8347 | .8427 | .0160 | 19.26 | 1½ | 42.1019 | | | |
| 1½ | 57.8138 | | | | 2 | 40.5963 | .5655 | .0396 | 39.28 |
| 2 | 53.0966 | | | | 2 | 39.7396 | | | |
| 1½ | 52.8357 | .8490 | .0186 | 21.13 | 1 | 39.7719 | .7700 | .0351 | 34.54 |
| 2 | 52.4416 | .4546 | .0398 | 45.01 | 1 | 39.0430 | .0385 | .0222 | 21.67 |
| 1½ | 50.0253 | .0343 | .0241 | 26.51 | 2 | 37.9630 | | | |
| 1 | 49.3917 | .3997 | .0331 | 36.14 | 1 | 37.3251 | .3195 | .0307 | 29.44 |
| 1½ | 48.7944 | .8010 | .0282 | 30.79 | 1 | 36.5090 | .5020 | .0398 | 37.85 |
| 2 | 48.7650 | | | | 3 | 35.4418 | | | |
| 2 | 45.2671 | | | | 1 | 35.4710 | .4395 | .0319 | 30.02 |
| 1½ | 45.2590 | .2654 | .0267 | 27.87 | 1 | 35.1990 | .1875 | .0385 | +35.92 |

Weighted mean..... +31.38

 V_a -25.61 V_d -20

Curvature..... -28

Radial velocity..... +5.3

 η BOÖTIS 950.*1907, July 18.
G. M. T. 13^h 57^mObserved by J. N. TRIBBLE.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 59.8053 | | | | 1 | 43.0955 | .0835 | .0332 | 33.82 |
| 1 | 59.0690 | .0730 | .0323 | +39.43 | 1 | 42.1179 | | | |
| 1 | 57.8528 | .8563 | .0295 | 35.51 | 1½ | 40.5776 | .5621 | .0362 | 35.91 |
| 1 | 57.0777 | .0807 | .0139 | 16.58 | 1 | 39.7823 | .7653 | .0304 | 29.91 |
| 1½ | 56.6654 | | | | 1 | 38.0089 | .9889 | .0278 | 26.93 |
| 1 | 53.1105 | | | | 1 | 37.9769 | | | |
| 1 | 52.8502 | .8512 | .0208 | 23.62 | 1 | 37.8012 | .7822 | .0177 | 17.06 |
| 1 | 52.4460 | .4470 | .0322 | 36.41 | 1 | 36.5180 | .4960 | .0338 | 32.04 |
| 1 | 45.2830 | | | | 1 | 35.4775 | .4535 | .0259 | +24.37 |
| 1 | 43.5729 | .5619 | .0287 | 29.43 | 1 | 35.4548 | | | |

Weighted mean..... +29.23

 V_a -25.61 V_d -20

Curvature..... -28

Radial velocity..... +3.1

*Check measurement.

SESSIONAL PAPER No. 25a

 η BOOTIS 9721907. Aug. 1
G. M. T. 13^h 39^mObserved by W. E. HARPER.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 59.8125 | | | | 1 | 47.2717 | .2733 | .0315 | 33.55 |
| 1 | 59.0699 | .0660 | .0253 | +30.89 | 1 | 47.1677 | .1693 | .0225 | 23.96 |
| 2 | 57.8529 | .8497 | .0229 | 27.57 | 1 | 47.0555 | .0571 | .0409 | 43.56 |
| 2 | 57.8249 | | | | 2 | 45.2721 | | | |
| 2 | 56.6066 | | | | 1½ | 45.2731 | .2751 | .0364 | 38.00 |
| 1 | 56.3701 | .3709 | .0347 | 41.05 | 2 | 43.5334 | | | |
| 1 | 55.1626 | .1642 | .0390 | 45.47 | 1 | 43.0770 | .0785 | .0332 | 33.90 |
| 2 | 54.0291 | | | | 2 | 40.5588 | .5589 | .0321 | 31.84 |
| 1½ | 52.8504 | .8494 | .0190 | 21.58 | 1½ | 39.7640 | .7620 | .0352 | 34.64 |
| 1 | 52.4609 | .4600 | .0452 | 51.12 | 2 | 39.7388 | | | |
| 2 | 52.2516 | | | | 2 | 37.9622 | | | |
| 1 | 50.0488 | .0488 | .0387 | 42.57 | 2 | 37.3332 | .3284 | .0306 | 37.97 |
| 1½ | 49.4060 | .4048 | .0386 | 42.57 | 2 | 36.5021 | .4960 | .0338 | +32.14 |
| 2 | 48.7684 | | | | 2 | 35.4334 | | | |

Weighted mean..... +36.02
 V_a -24.14
 V_d -24
 Curvature..... -28

Radial velocity..... +11.4

 η BOOTIS 990.1907. Aug. 7.
G. M. T. 13^h 58^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 77.5311 | .3820 | .0765 | +34.73 | 2 | 68.8751 | | | |
| 2 | 77.5065 | | | | 1½ | 68.0457 | .9357 | .0875 | 37.45 |
| 1 | 77.2249 | .0775 | .0838 | 37.88 | 2 | 67.6516 | .5636 | .0768 | 32.87 |
| 1½ | 75.4840 | .3450 | .0687 | 30.91 | 2 | 64.6397 | .5717 | .0641 | 26.92 |
| 2 | 75.3861 | | | | 2 | 61.4950 | | | |
| 1½ | 74.5448 | .4108 | .0755 | 33.75 | 1½ | 60.5500 | .5045 | .0777 | 31.62 |
| 2 | 73.1143 | .9873 | .0597 | 26.45 | 2 | 58.9771 | .9411 | .0833 | 33.57 |
| 2 | 72.8337 | .7101 | .0719 | 31.71 | 1 | 58.6538 | .6200 | .0878 | 35.38 |
| 3 | 72.1565 | .0350 | .0677 | 29.79 | 2 | 56.4377 | | | |
| 2 | 72.0721 | | | | 1 | 50.0635 | .0820 | .0726 | 27.66 |
| 2 | 70.0758 | .9700 | .0879 | 38.15 | 1½ | 48.1930 | .2266 | .0853 | +32.07 |
| 2 | 69.3246 | .2233 | .0691 | 21.78 | 2 | 46.3541 | | | |
| 2 | 68.9702 | .8732 | .0867 | 37.37 | | | | | |

Weighted mean..... +32.66
 V_a -23.09
 V_d -28
 Curvature..... -28

Radial velocity..... -9.0

9-10 EDWARD VII., A. 1910

 η BOÖTIS 1231.1908. Jan. 14.
G. M. T. 22^h 00^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 57 8434 | | | | 1½ | 44 2401 | 2266 | 0326 | 33.67 |
| 2 | 57 8277 | 8047 | 0221 | -26.61 | 2 | 41 3012 | | | |
| 1½ | 54 7647 | | | | 2 | 40 5147 | 5000 | 0259 | 25.69 |
| 2 | 53 1290 | | | | 2 | 39 7496 | | | |
| 1 | 52 8248 | 8048 | 0256 | 29.08 | 2 | 39 7099 | 6959 | 0309 | 30.40 |
| 2 | 52 3886 | 3790 | 0358 | 40.49 | 1½ | 39 0059 | 9925 | 0238 | 23.23 |
| 2 | 52 2765 | | | | 2 | 37 9716 | | | |
| 2 | 49 9963 | 9788 | 0313 | 34.43 | 2 | 37 2765 | 2630 | 0258 | 24.74 |
| 1½ | 49 3592 | 3340 | 0334 | 36.47 | 1½ | 36 4496 | 4350 | 0272 | 25.87 |
| 2 | 48 7851 | | | | 2 | 35 4474 | | | |
| 1½ | 48 7630 | 7470 | 0258 | 28.00 | 1½ | 35 4212 | 4043 | 0233 | 21.92 |
| 2 | 45 2867 | | | | 1½ | 35 1325 | 1150 | 0340 | -31.72 |
| 1½ | 45 2195 | 2060 | 0327 | 34.14 | | | | | |

Weighted mean..... - 29.76

 V_a - 26.58 V_d 12

Curvature..... - 28

Radial velocity..... - 3.3

 η BOÖTIS 1231.*1908. Jan. 14.
G. M. T. 22^h 00^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59 8174 | | | | 1 | 44 2521 | | | |
| 1 | 57 8144 | 8084 | 0182 | -21.91 | 1 | 41 2816 | | | |
| 1 | 56 6735 | | | | 1 | 40 4982 | 5032 | 0227 | 22.51 |
| 1 | 53 1182 | | | | 1 | 39 7312 | | | |
| 1 | 52 8153 | 8133 | 0171 | 19.42 | 2 | 39 6870 | 6915 | 0333 | 34.73 |
| 1½ | 52 3882 | 3872 | 0276 | 31.21 | 1½ | 37 9558 | | | |
| 2 | 52 2605 | | | | 1 | 37 2517 | 2567 | 0321 | 33.66 |
| 1 | 50 0076 | | | | 1 | 36 4308 | 4358 | 0264 | 25.00 |
| 2 | 49 9827 | 9847 | 0254 | 27.94 | 2 | 35 4251 | | | |
| 1 | 49 3633 | | | | 1 | 35 3991 | 4041 | 0264 | 24.84 |
| 1 | 49 3360 | 3390 | 0272 | 29.70 | 1 | 30 8092 | | | |
| 1 | 49 1028 | | | | 1 | 30 8499 | 8543 | 0213 | -19.12 |
| 1 | 48 7675 | | | | 1 | 29 9064 | | | |
| 1 | 48 7445 | 7485 | 0155 | 16.81 | | | | | |

Weighted mean..... - 25.62

 V_a + 26.58 V_d 12

Curvature..... - 28

Radial velocity..... + 0.6

*Check measurement.

SESSIONAL PAPER No. 25a

 η BOÖTIS 1294.1908, Jan. 27.
G. M. T. 20^h 12^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 76.7049 | | | | 2 | 60.2453 | .2638 | .0714 | 29.34 |
| 2 | 76.3139 | .3760 | .0487 | -22.25 | 2 | 59.7232 | .7437 | .0627 | 25.11 |
| 2 | 74.9780 | | | | 2 | 58.3645 | .3890 | .0767 | 31.14 |
| 2 | 74.9412 | .9965 | .0686 | 31.07 | 2 | 57.4642 | .4818 | .0701 | 28.32 |
| 2 | 74.0085 | .0615 | .0691 | 31.16 | 2 | 56.3435 | | | |
| 2 | 73.3760 | | | | 2 | 56.7436 | .7596 | .0669 | 26.90 |
| 2 | 72.6176 | .6656 | .0980 | 30.77 | 2 | 56.0215 | .0370 | .0559 | 22.36 |
| 1½ | 71.7327 | | | | 1 | 50.9975 | | | |
| 3 | 71.6719 | .7194 | .0628 | 27.88 | 2 | 49.9284 | .9324 | .0677 | 26.00 |
| 2 | 69.6070 | .6485 | .0647 | 28.27 | 2 | 48.0797 | .0787 | .0806 | 30.63 |
| 2 | 68.8730 | .1130 | .0794 | 34.46 | 2 | 46.4398 | | | |
| 2 | 68.5172 | .5572 | .0705 | 30.60 | 2 | 46.3377 | .3310 | .0839 | 31.46 |
| 2 | 68.5312 | | | | 2 | 38.2531 | .2267 | .0794 | 28.34 |
| 2 | 67.6069 | .6434 | .0735 | 31.75 | 2 | 36.2270 | | | |
| 2 | 64.2811 | .3091 | .0754 | 31.82 | 2 | 36.0357 | .0627 | .0878 | 30.90 |
| 2 | 61.3235 | | | | 2 | 33.1311 | .0940 | .0779 | -26.87 |

Weighted mean..... -29.00

 V_a +25.27 V_d +.16

Curvature..... - .28

Radial velocity..... 3.8

 η BOÖTIS 1307.1908, Jan. 29.
G. M. T. 21^h 14^mObserved by J. S. PLASKETT.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 76.7556 | | | | 2 | 59.7720 | .7402 | .0662 | 27.12 |
| 1½ | 76.3539 | .3649 | .0598 | -27.37 | 2 | 58.4380 | .4030 | .0567 | 23.02 |
| 2 | 75.0276 | | | | 2 | 57.5179 | .4802 | .0715 | 28.86 |
| 2 | 74.9901 | .9980 | .0660 | 29.92 | 2 | 56.8023 | .7628 | .0637 | 23.59 |
| 2 | 74.0388 | .0640 | .0666 | 30.02 | 2 | 56.3977 | | | |
| 2 | 73.4219 | | | | 1 | 56.0711 | .0300 | .0629 | 25.15 |
| 2 | 72.6605 | .6620 | .0726 | 32.41 | 2 | 50.0571 | | | |
| 3 | 71.7218 | .7208 | .0614 | 27.24 | 2 | 49.9803 | .9258 | .0851 | 32.70 |
| 2 | 69.6614 | .6552 | .0590 | 25.81 | 2 | 48.1479 | .0864 | .0685 | 26.01 |
| 2 | 68.9241 | .9159 | .0765 | 33.31 | 2 | 46.4398 | | | |
| 3 | 68.5710 | .5620 | .0657 | 28.53 | 2 | 46.4076 | .3415 | .0734 | 27.56 |
| 2 | 68.6280 | | | | 2 | 38.3121 | .2251 | .0810 | 28.88 |
| 2 | 67.6542 | .6427 | .0742 | 32.03 | 2 | 36.2864 | | | |
| 2 | 64.3451 | .3251 | .0594 | 25.08 | 2 | 36.1037 | .0107 | .0798 | 28.06 |
| 2 | 61.3704 | | | | 2 | 33.1978 | .0938 | .0781 | -26.96 |
| 1½ | 60.2939 | .2634 | .0748 | 30.75 | 2 | 33.2792 | | | |

Weighted mean..... -28.32

 V_a +24.95 V_d +.13

Curvature..... - .28

Radial velocity..... - 3.5

9-10 EDWARD VII., A. 1910

 η BOÖTIS 1332.Feb. 17, 1908.
G. M. T. 22^h 30^mObserved by J. S. PLASKETT.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 76.7212 | | | | 2 | 58.3842 | .3982 | .0615 | 24.97 |
| 2 | 76.3188 | .3628 | .0619 | -28.33 | 2 | 57.4824 | .4954 | .0565 | 22.80 |
| 2 | 74.8946 | | | | 2 | 56.7485 | .7600 | .0665 | 26.71 |
| 2 | 74.9365 | .9982 | .0658 | 29.83 | 2 | 56.3452 | | | |
| 2 | 74.0249 | .0649 | .0657 | 29.61 | 1 | 56.0291 | .0393 | .0536 | 21.43 |
| 2 | 73.3885 | | | | 2 | 53.4001 | .4061 | .0624 | 24.52 |
| 2 | 72.6378 | .6756 | .0390 | 25.34 | 2 | 49.0003 | | | |
| 3 | 71.6874 | .7236 | .0586 | 26.00 | 2 | 49.9357 | .9359 | .0750 | 28.82 |
| 2 | 69.6200 | .6528 | .0614 | 26.86 | 2 | 48.0881 | .0853 | .0696 | 26.43 |
| 2 | 68.8936 | .9251 | .0673 | 29.30 | 2 | 46.4381 | | | |
| 3 | 68.5431 | .5741 | .0536 | 23.18 | 2 | 46.3480 | .3422 | .0727 | 27.50 |
| 2 | 68.5930 | | | | 2 | 38.2430 | .2240 | .0821 | 29.28 |
| 3 | 67.6210 | .6505 | .0664 | 28.66 | 2 | 36.2164 | | | |
| 2 | 64.2952 | .3192 | .0653 | 27.57 | 2 | 36.0427 | .0202 | .0703 | 24.72 |
| 2 | 61.3281 | | | | 2 | 33.1294 | .1019 | .0700 | -24.16 |
| 2 | 60.2510 | .2682 | .0700 | 28.78 | 2 | 33.2010 | | | |
| 2 | 59.7464 | .7629 | .0435 | 17.82 | | | | | |

Weighted mean -25.21
 V_a +20.45
 V_d +.12
Curvature -.28
Radial velocity -5.2

 η BOÖTIS 1357.1908. Feb. 24.
G. M. T. 19^h 06^mObserved by W. E. HARPER.
Measured by

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 76.7176 | | | | 1 | 67.6130 | .6450 | .0719 | 30.99 |
| 1 | 76.3250 | .3710 | .0537 | -24.59 | 2 | 63.2135 | .2395 | .0700 | 29.33 |
| $\frac{1}{2}$ | 74.9671 | .0101 | .0539 | 24.42 | 2 | 61.3207 | | | |
| 2 | 73.3845 | | | | 1 | 60.2534 | .2750 | .0632 | 25.97 |
| $\frac{1}{2}$ | 72.1053 | .1450 | .0562 | 25.06 | 2 | 58.3903 | .4073 | .0524 | 21.27 |
| 1 | 71.6970 | .7365 | .0457 | 20.34 | 2 | 56.3395 | | | |
| 2 | 71.1225 | | | | 2 | 56.0048 | .0208 | .0721 | 28.84 |
| 2 | 68.5883 | | | | 2 | 52.0625 | .0730 | .0528 | -20.59 |
| $\frac{1}{2}$ | 68.5422 | .5762 | .0515 | 22.35 | 2 | 49.9913 | | | |
| $\frac{1}{2}$ | 67.9892 | .0212 | .0683 | 28.44 | | | | | |

Weighted mean -25.27
 V_a +18.26
 V_d +.16
Curvature -.28
Radial velocity -7.1

SESSIONAL PAPER No. 25a

 η BOÖTIS 1446.1908. Mar. 30.
G. M. T. 21^h 52^mObserved by W. E. HARPER.
Measured by)

| Region. | Settings I. | | Difference in Revolutions. | Settings II. | | Difference in Revolutions. | Mean Difference | Velocity. |
|---------|-------------|-------------|----------------------------------|--------------|-------------|----------------------------------|--------------------|-----------|
| | Star. | Comparison. | | Star. | Comparison. | | | |
| 4 | 395 | 424 | 029 | 350 | 324 | 026 | 275 | -12.88 |
| 5 | 410 | 435 | 025 | 336 | 314 | 022 | 235 | 10.57 |
| 6 | 411 | 437 | 026 | 346 | 306 | 040 | 280 | 12.29 |
| 7 | 417 | 446 | 029 | 330 | 321 | 009 | 190 | 8.15 |
| 8 | 441 | 465 | 024 | 317 | 296 | 021 | 225 | 9.43 |
| 9 | 450 | 471 | 021 | 320 | 280 | 030 | 255 | 10.45 |
| 10 | 433 | 475 | 040 | 304 | 276 | 028 | 340 | -13.60 |

Standard 33
 Weighted mean -10.72
 V_a -3.98
 V_d -25
 Radial velocity -7.0

 η BOÖTIS 1446.*1908. Mar. 30.
G. M. T. 21^h 52^mObserved by W. E. HARPER.
Measured by C. R. WESTLAND.

| W | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---|-------------------------|--------------------------------|--------------------------------------|-----------|----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 75.0031 | | | | 2 | 58.3770 | 4406 | 0191 | 7.75 |
| 2 | 75.0052 | 0377 | 0263 | -11.92 | 2 | 57.4580 | 5231 | 0288 | 11.62 |
| 2 | 74.0795 | 1152 | 0154 | 6.94 | 2 | 56.7254 | 7917 | 0348 | 13.98 |
| 2 | 73.3860 | | | | 2 | 56.2921 | | | |
| 2 | 72.6643 | 7044 | 0302 | 13.48 | 1 | 56.0050 | 0732 | 6197 | 7.88 |
| 3 | 71.7097 | 7522 | 0300 | 13.31 | 2 | 49.9236 | | | |
| 2 | 68.9128 | 9623 | 0301 | 13.10 | 1 | 49.8982 | 9763 | 0346 | 13.20 |
| 2 | 68.5557 | 6061 | 0216 | 9.38 | 2 | 48.0465 | 1272 | 0321 | 12.19 |
| 2 | 68.5769 | | | | 2 | 46.3300 | | | |
| 2 | 67.6457 | 6970 | 0199 | 9.32 | 2 | 46.3083 | 3908 | 0241 | 9.05 |
| 2 | 61.2856 | | | | 3 | 38.1702 | 2679 | 0332 | -13.62 |
| 2 | 60.2494 | 3100 | 0282 | 11.59 | 2 | 36.0923 | | | |
| 2 | 59.7264 | 7878 | 0190 | 7.62 | | | | | |

Weighted mean -10.94
 V_a -3.98
 V_d -25
 Curvature -28
 Radial velocity -7.5

*Check measurement.

9-10 EDWARD VII., A. 1910

 η BOÖTIS 1446.*1908, March 30.
G. M. T. 21^h 52^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 76 7922 | | | | 1 | 59 7825 | 7820 | 0244 | 10.60 |
| 1 | 76 4392 | 4142 | 0105 | -4.80 | 1 | 58 4374 | 4384 | 0213 | 8.64 |
| 1 | 75 0585 | | | | 1 | 57 5302 | 5322 | 0197 | 7.95 |
| 1 | 75 0715 | 0465 | 0175 | 7.92 | 1 | 56 7981 | 8011 | 0154 | 6.19 |
| 2 | 73 4509 | | | | 1 | 56 3536 | | | |
| 1 | 72 7325 | 7074 | 0272 | 12.13 | 2 | 49 9915 | | | |
| 2 | 71 7755 | 7505 | 0317 | 14.07 | 1 | 49 9582 | 9712 | 0289 | 11.09 |
| 1 | 68 9752 | 9542 | 0382 | 16.62 | 1 | 48 1122 | 1272 | 0321 | 12.19 |
| 1 | 68 6257 | 6047 | 0230 | 9.98 | 2 | 46 4180 | | | |
| 2 | 68 6416 | | | | 1 | 46 3655 | 3845 | 0304 | 11.43 |
| 1 | 67 7025 | 6945 | 0224 | 9.67 | 1 | 38 2275 | 2505 | 0406 | -16.63 |
| 1 | 61 3480 | | | | 1 | 36 1572 | | | |
| 1 | 60 3231 | 3211 | 0171 | 7.02 | | | | | |

Weighted mean..... -10.39

 V_d +3.98 V_d25

Curvature..... .28

Radial velocity..... -6.9

*Check measurement.

 η BOÖTIS 1513.1908, May 4.
G. M. T. 18^h 13^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 75 1160 | | | | 2 | 63 3747 | | | |
| 2 | 74 2116 | 2076 | 0087 | +3.91 | 1 | 63 3747 | 3635 | 0061 | 2.55 |
| 2 | 73 4946 | | | | 1 | 60 3917 | 3785 | 0109 | 4.47 |
| 2 | 72 8120 | 8070 | 0080 | 3.55 | 1 | 59 8668 | 8533 | 0189 | 7.71 |
| 1 | 72 5446 | 5394 | | | 2 | 58 8243 | | | |
| 2 | 72 2822 | 2770 | 0131 | 5.82 | 2 | 58 5330 | 5188 | 0112 | 4.54 |
| 2 | 71 8622 | 8567 | 0128 | 5.63 | 1 | 56 8700 | 8540 | 0081 | 3.24 |
| 1 $\frac{1}{2}$ | 69 7922 | 7857 | 0155 | 6.76 | 2 | 56 3934 | | | |
| 1 | 69 0562 | 0492 | | | 2 | 53 9788 | | | |
| 1 | 68 7040 | 6967 | 0159 | 6.92 | 1 | 52 1672 | 1482 | 0164 | 6.36 |
| 2 | 68 6835 | | | | 1 | 48 1835 | 1620 | 0087 | +3.30 |
| 1 | 67 7903 | 7823 | 0150 | 6.46 | 2 | 46 4436 | | | |
| 1 | 65 5445 | 5350 | 0056 | 2.37 | | | | | |

Weighted mean..... +4.91

 V_d -11.19 V_d17

Curvature..... .28

Radial velocity..... -6.7

SESSIONAL PAPER No. 25a

 η BOÖTIS 1537.1908, May 23.
G. M. T. 16^h 00^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 76 9548 | ..... | ..... | ..... | 1 | 68 2353 | 2063 | 0138 | 5 93 |
| 1 | 76 9700 | 9334 | 0152 | 6 93 | 2 | 67 4948 | 4461 | 0085 | 3 63 |
| 1 | 76 6302 | 5937 | 0200 | 9 10 | 1 | 63 4283 | ..... | ..... | ..... |
| 1 | 75 2687 | 2326 | 0273 | 12 31 | 1 | 59 9277 | 8062 | 0339 | 13 79 |
| 2 | 75 2128 | ..... | ..... | ..... | 1 | 59 3672 | 3358 | 0362 | 14 69 |
| 2 | 73 5876 | ..... | ..... | ..... | 2 | 56 4245 | ..... | ..... | ..... |
| 1 | 72 9026 | 8696 | 0064 | 2 84 | 1 | 52 7616 | 7366 | 0308 | 11 98 |
| 1½ | 71 9679 | 9359 | 0303 | 13 36 | 1 | 50 0213 | ..... | ..... | ..... |
| 1 | 71 9354 | ..... | ..... | ..... | 1½ | 48 1824 | 1643 | 0168 | 6 35 |
| 2 | 69 1577 | 1285 | 0283 | 12 25 | 2 | 46 4392 | 4238 | 0315 | +11 74 |
| 1 | 68 7609 | ..... | ..... | ..... | 2 | 46 4258 | ..... | ..... | ..... |

Weighted mean 9 6

 V_d -17 97 V_s -10

Curvature -28

Radial velocity -8 7

 η BOÖTIS 1553.1908, May 25.
G. M. T. 15^h 58^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 76 9679 | ..... | ..... | ..... | 2 | 68 7945 | 8090 | 0225 | 9 69 |
| 1 | 77 3242 | 3499 | 0444 | 20 24 | 2 | 68 7714 | ..... | ..... | ..... |
| 1 | 76 6597 | 6853 | 0371 | 16 84 | 2 | 67 8874 | 9004 | 0322 | 13 78 |
| 1 | 76 4693 | 4923 | 0189 | 8 58 | 2 | 64 5208 | 5278 | 0202 | 8 46 |
| 1 | 75 2271 | ..... | ..... | ..... | 1 | 63 4552 | 4606 | 0371 | 15 43 |
| 2 | 74 3368 | 3568 | 0215 | 9 61 | 2 | 63 4326 | ..... | ..... | ..... |
| 2 | 73 6031 | ..... | ..... | ..... | 1 | 61 4657 | 4657 | 0300 | 12 30 |
| 2 | 72 3932 | 4112 | 0210 | 9 26 | 2 | 60 4492 | 4482 | 0214 | 8 73 |
| 1 | 71 9847 | 0027 | 0354 | 15 57 | 2 | 59 9312 | 9297 | 0394 | 15 99 |
| 2 | 71 3184 | ..... | ..... | ..... | 2 | 59 3758 | 3723 | 0464 | 18 83 |
| 2 | 69 8968 | 9123 | 0302 | 13 10 | 2 | 58 8903 | 8853 | 0275 | -11 08 |
| 1 | 69 1583 | 1728 | 0186 | 8 03 | 2 | 56 4272 | ..... | ..... | ..... |

Weighted mean 12 38

 V_d -18 59 V_s -10

Curvature -28

Radial velocity -6 6

9-10 EDWARD VII., A. 1910

 η BOÖTIS 1553.*1905. May 23.
G. M. T. 15^h 58^mObserved by T. H. PARKER.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 76.8899 | | | | 2 | 68.7225 | 8120 | .0255 | 10.99 |
| 1 | 77.2379 | .3419 | .0364 | +16.60 | 2 | 68.6957 | | | |
| 2 | 76.5803 | .6833 | .0351 | 15.93 | 2 | 67.8170 | .9050 | .0368 | 15.73 |
| 1 | 76.3967 | .4997 | .0263 | 11.91 | 2 | 64.4485 | .5294 | .0219 | 9.24 |
| 2 | 75.1498 | | | | 2 | 63.3766 | .4560 | .0325 | 13.52 |
| 3 | 74.2572 | .3557 | .0202 | 9.03 | 2 | 63.3594 | | | |
| 2 | 73.5255 | | | | 1 | 61.3866 | .4610 | .0253 | 10.37 |
| 2 | 72.3153 | .4103 | .0201 | 8.84 | 2 | 60.3764 | .4489 | .0221 | 9.02 |
| 2 | 71.9030 | .3973 | .0300 | 13.20 | 2 | 59.8471 | .9186 | .0283 | 11.49 |
| 2 | 71.8607 | | | | 1 | 59.2900 | .3600 | .0341 | 13.78 |
| 2 | 71.2438 | | | | 2 | 58.8184 | .8874 | .0296 | +11.96 |
| 2 | 69.8265 | .9175 | .0354 | 15.36 | 2 | 56.3496 | | | |
| 2 | 69.0868 | 1768 | .0226 | 9.76 | | | | | |

Weighted mean..... -12.16
 V_a -18.59
 V_d -10
Curvature..... -28

Radial velocity... - 6.8

*Different standard.

 η BOÖTIS 1621.1908. June 22.
G. M. T. 14^h 10^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 76.8898 | | | | 2 | 67.8377 | .8610 | .0432 | 18.53 |
| 2 | 76.5947 | .6227 | .0450 | +20.47 | 2 | 65.5907 | .6127 | .0392 | 16.58 |
| 2 | 74.2843 | .3110 | .0440 | 19.71 | 2 | 64.4965 | .5180 | .0514 | 21.59 |
| 2 | 74.0261 | .0526 | .0477 | 21.32 | 2 | 63.3773 | | | |
| 2 | 73.5353 | | | | 2 | 60.4210 | .4413 | .0439 | 17.91 |
| 2 | 72.8694 | .8954 | .0322 | 14.30 | 2 | 59.8945 | .9145 | .0522 | 21.24 |
| 2 | 72.5840 | .6100 | .0353 | 15.64 | 2 | 58.8142 | | | |
| 2 | 72.3438 | .3693 | .0418 | 18.47 | 2 | 58.8748 | .8948 | .0620 | 25.04 |
| 3 | 71.9275 | .9528 | .0472 | 20.81 | 2 | 58.5401 | .5601 | .0521 | 20.37 |
| 2 | 71.2520 | | | | 2 | 53.9551 | | | |
| 2 | 69.8502 | .8744 | .0483 | 21.01 | 2 | 52.1673 | .1880 | .0505 | -19.54 |
| 3 | 68.7500 | .7735 | .0400 | 17.28 | 2 | 49.9791 | | | |
| 2 | 68.7025 | | | | | | | | |

Weighted mean..... +19.40
 V_a -24.75
 V_d -17
Curvature..... -28

Radial velocity... - 5.8

SESSIONAL PAPER No. 25a

 η BOÖTIS 1621.*1908. June 22.
G. M. T. 14^h 10^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 76 9513 | | | | 3 | 67 8975 | 8633 | 0455 | 20 88 |
| 2 | 76 6545 | 6195 | 0458 | +20 84 | 2 | 65 6520 | 6150 | 0415 | 17 55 |
| 2 | 74 3483 | 3118 | 0448 | 20 07 | 2 | 64 5563 | 5168 | 0502 | 21 08 |
| 2 | 74 0780 | 0418 | 0369 | 16 50 | 2 | 63 4410 | | | |
| 2 | 73 5981 | | | | 2 | 60 4858 | 4438 | 0464 | 18 93 |
| 2 | 72 9294 | 8934 | 0392 | 13 40 | 2 | 59 9466 | 9046 | 0423 | 17 22 |
| 2 | 72 6463 | 6103 | 0356 | 15 77 | 2 | 58 8764 | | | |
| 2 | 72 4084 | 3722 | 0347 | 15 34 | 2 | 58 9274 | 8859 | 0531 | 21 45 |
| 2 | 71 9888 | 9527 | 0471 | 20 77 | 2 | 58 5948 | 5533 | 0453 | 17 71 |
| 2 | 71 3110 | | | | 2 | 54 0116 | | | |
| 2 | 69 9688 | 8748 | 0487 | 21 18 | 2 | 52 2260 | 1960 | 0585 | +22 64 |
| 2 | 68 8137 | 7802 | 0467 | 20 17 | 2 | 50 0224 | | | |
| 2 | 68 7675 | | | | | | | | |

Weighted mean -18 91

 V_a -24 75 V_d -17

Curvature -28

Radial velocity -6 3

*Check measurement.

 η BOÖTIS 1663.*1908. July 6.
G. M. T. 14^h 40^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Region. | Settings I. | | Difference in Revolutions. | Settings II. | | Difference in Revolutions. | Mean Difference | Velocity. |
|---------|-------------|-------------|----------------------------|--------------|-------------|----------------------------|-----------------|-----------|
| | Star. | Comparison. | | Star. | Comparison. | | | |
| 6 | 325 | 359 | 034 | 688 | 643 | 045 | 040 | +19 04 |
| 7 | 334 | 363 | 029 | 686 | 641 | 045 | 037 | 16 98 |
| 8 | 341 | 378 | 037 | 668 | 632 | 035 | 036 | 15 95 |
| 9 | 334 | 378 | 044 | 676 | 632 | 044 | 044 | 18 92 |
| 10 | 347 | 387 | 040 | 672 | 619 | 053 | 046 | 19 14 |
| 11 | 350 | 403 | 053 | 660 | 603 | 057 | 035 | 22 11 |
| 12 | 372 | 411 | 039 | 650 | 603 | 047 | 043 | 16 65 |
| 13 | 368 | 414 | 046 | 650 | 605 | 045 | 046 | 17 30 |
| 14 | 378 | 425 | 047 | 650 | 600 | 050 | 048 | 17 47 |
| 15 | 397 | 445 | 048 | 634 | 579 | 055 | 052 | 18 30 |
| 16 | 407 | 458 | 051 | 628 | 564 | 064 | 067 | 19 49 |
| 17 | 430 | 467 | 037 | 604 | 554 | 050 | 044 | +14 56 |

Weighted mean +17 99

1519 Standard +41

 V_a +18 40 V_d -25 77 V_c -17

Radial velocity -7 6

9-10 EDWARD VII., A. 1910

 η BOÖTIS 1663.1908. July 5.
G. M. T. 14^h 40^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Region. | Settings I. | | Difference in Revolutions. | Settings II. | | Difference in Revolutions. | Mean Difference | Velocity. |
|---------|-------------|-------------|----------------------------------|--------------|-------------|----------------------------------|--------------------|-----------|
| | Star. | Comparison. | | Star. | Comparison. | | | |
| 5 | 021 | 970 | 051 | 205 | 246 | 041 | 046 | +22.72 |
| 6 | 009 | 975 | 034 | 201 | 250 | 049 | 042 | 20.00 |
| 7 | 021 | 966 | 056 | 206 | 254 | 048 | 052 | 23.87 |
| 8 | 021 | 965 | 056 | 212 | 251 | 039 | 047 | 20.82 |
| 9 | 009 | 967 | 042 | 213 | 253 | 040 | 041 | 17.63 |
| 10 | 995 | 958 | 037 | 220 | 266 | 046 | 041 | 17.06 |
| 11 | 008 | 955 | 053 | 229 | 270 | 041 | 047 | 18.89 |
| 12 | 984 | 949 | 035 | 219 | 284 | 065 | 050 | 19.41 |
| 13 | 973 | 944 | 029 | 241 | 283 | 042 | 036 | 13.54 |
| 14 | 989 | 927 | 062 | 240 | 284 | 044 | 053 | 19.29 |
| 15 | 970 | 914 | 056 | 250 | 301 | 051 | 053 | 18.66 |
| 16 | 967 | 917 | 050 | 255 | 311 | 056 | 053 | 18.13 |
| 17 | 950 | 905 | 045 | 265 | 319 | 054 | 048 | 15.89 |
| 18 | 951 | 890 | 041 | 285 | 324 | 039 | 040 | 12.82 |
| 19 | 942 | 877 | 065 | 291 | 335 | 044 | 054 | +16.74 |

Weighted mean..... +18.36

1520 Standard..... = .38

 V_r -18.74 V_{α} -25.77 V_d -17

Radial velocity..... -7.2

 η BOÖTIS 1710.1908. July 15.
G. M. T. 14^h 11^mObserved by J. B. CANNON.
Measured by W. E. HARPER.

| Region. | Settings I. | | Difference in Revolutions. | Settings II. | | Difference in Revolutions. | Mean Difference | Velocity. |
|---------|-------------|-------------|----------------------------------|--------------|-------------|----------------------------------|--------------------|-----------|
| | Star. | Comparison. | | Star. | Comparison. | | | |
| 6 | 435 | 396 | 039 | 456 | 405 | 051 | 045 | -21.42 |
| 7 | 426 | 386 | 040 | 445 | 407 | 038 | 039 | 17.90 |
| 8 | 426 | 386 | 040 | 442 | 391 | 051 | 045 | 19.93 |
| 9 | 448 | 395 | 053 | 439 | 392 | 047 | 050 | 21.50 |
| 10 | 448 | 400 | 048 | 434 | 395 | 039 | 043 | 17.89 |
| 11 | 454 | 391 | 063 | 425 | 383 | 043 | 053 | 21.31 |
| 12 | 436 | 389 | 037 | 444 | 400 | 044 | 040 | 15.53 |
| 13 | 448 | 400 | 048 | 444 | 375 | 060 | 058 | 21.81 |
| 14 | 455 | 405 | 050 | 439 | 400 | 039 | 045 | 16.38 |
| 15 | 451 | 396 | 055 | 450 | 390 | 060 | 057 | 20.06 |
| 16 | 461 | 391 | 070 | 451 | 395 | 056 | 063 | 21.55 |
| 17 | 425 | 390 | 035 | 452 | 398 | 054 | 044 | +14.56 |

Weighted mean..... +19.15

1520 Standard..... + .38

 V_r +19.53 V_{α} -25.71 V_d -24

Radial velocity..... -6.4

SESSIONAL PAPER No. 25a

 η BOOTIS 17921908, Aug. 19.
G. M. T. 13^h 18^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Region. | Settings I. | | Difference in Revolutions | Settings II. | | Difference in Revolutions | {Mean Difference | Velocity. |
|---------|-------------|-------------|---------------------------------|--------------|------------|---------------------------------|---------------------|-----------|
| | Star | Comparison. | | Star | Comparison | | | |
| 5 | 802 | 817 | 015 | 718 | 650 | 028 | 022 | +10 86 |
| 6 | 812 | 824 | 012 | 697 | 673 | 024 | 018 | 8 56 |
| 7 | 815 | 834 | 019 | 710 | 671 | 039 | 029 | 13 31 |
| 8 | 829 | 846 | 017 | 693 | 670 | 023 | 026 | 11 51 |
| 9 | 828 | 841 | 013 | 681 | 660 | 021 | 025 | 10 72 |
| 10 | 831 | 860 | 029 | 685 | 654 | 031 | 030 | 12 45 |
| 11 | 837 | 865 | 028 | 682 | 644 | 038 | 033 | 13 23 |
| 12 | 842 | 868 | 026 | 687 | 654 | 033 | 029 | 11 25 |
| 13 | 853 | 885 | 042 | 668 | 640 | 028 | 035 | 13 16 |
| 14 | 865 | 805 | 030 | 660 | 619 | 041 | 036 | 13 10 |
| 15 | 864 | 902 | 039 | 636 | 600 | 036 | 037 | 13 02 |
| 16 | 876 | 909 | 033 | 637 | 591 | 046 | 039 | +13 29 |

Weighted mean +12 04
 1519 Standard..... + 41
 V_a - 20 04
 V_d - 28
 Radial velocity..... - 7 9

 η BOOTIS 1867.1908, Sept. 7.
G. M. T. 12^h 57^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 76 9031 | | | | 2 | 71 8856 | | | |
| 1 $\frac{1}{2}$ | 77 2336 | 2508 | 0215 | + 9 80 | 1 | 68 7611 | 7763 | 0428 | 18 49 |
| 1 $\frac{1}{2}$ | 76 6039 | 6189 | 0452 | 20 61 | 2 | 68 7171 | | | |
| 1 | 75 8642 | 8777 | 0405 | 18 35 | 1 | 67 8216 | 8366 | 0188 | 8 06 |
| 1 $\frac{1}{2}$ | 72 8696 | 8798 | 0166 | 7 37 | 2 | 63 3916 | | | |
| 1 $\frac{1}{2}$ | 72 5992 | 6116 | 0369 | 16 35 | 1 | 60 4216 | 4276 | 0302 | 12 35 |
| 2 | 71 9211 | 9371 | 0315 | 13 89 | $\frac{1}{2}$ | 59 3391 | 3441 | 0345 | 22 13 |

Weighted mean..... +14 18
 V_a - 13 88
 V_d - 39
 Curvature..... - 28
 Radial velocity..... - 0 3

9-10 EDWARD VII., A. 1910

η BOÖTIS 2115.

1909. Jan. 7.
G. M. T. 23^h 23^m

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 76 6775 | | | | 2 | 69 3445 | 3612 | 0260 | 11 39 |
| 2 | 76 6430 | 6575 | 0344 | -15 82 | 2 | 68 8810 | 9002 | 0381 | 16 65 |
| 2 | 76 3060 | 3200 | 0301 | 13 79 | 2 | 68 5537 | | | |
| 2 | 74 9547 | | | | 2 | 68 5247 | 5245 | 0502 | 21 80 |
| 1 | 74 9365 | 9467 | 0464 | 21 11 | 2 | 67 6056 | 6244 | 0421 | 18 24 |
| 1 | 74 6052 | 0152 | 0471 | 21 29 | 2 | 67 2315 | 2501 | 0393 | 17 02 |
| 2 | 73 7510 | 7610 | 0413 | 18 63 | 2 | 65 3890 | 4052 | 0359 | 15 30 |
| 2 | 73 3481 | | | | 1 | 64 2927 | 3075 | 0360 | 15 30 |
| 2 | 72 6167 | 6277 | 0425 | 19 08 | 2 | 63 2724 | | | |
| 2 | 72 3162 | 3279 | 0500 | 25 09 | 2 | 63 2091 | 2230 | 0486 | 20 41 |
| 2 | 71 6667 | 6810 | 0394 | 17 53 | 2 | 58 7025 | 7188 | 0387 | -15 79 |
| 2 | 71 0812 | | | | 2 | 58 7427 | | | |
| 2 | 69 6012 | 6173 | 0409 | 17 91 | | | | | |

Weighted mean - 17 88
V_a + 26 69
V_d + 04
Curvature 28

Radial velocity + 8 6

η BOÖTIS 2209.

1906. Jan. 30.
G. M. T. 18^h 37^m

Observed by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 81 7544 | | | | 1 | 67 6626 | 6721 | 0448 | 19 35 |
| 1 | 80 5548 | 5772 | 0398 | -18 75 | $\frac{1}{2}$ | 66 5389 | 5481 | 0351 | 15 02 |
| 2 | 76 7524 | | | | $\frac{1}{2}$ | 64 3381 | 3469 | 0376 | 15 87 |
| 1 | 76 7084 | 7234 | 0440 | 20 20 | 2 | 61 3366 | | | |
| 1 | 76 3728 | 3878 | 0369 | 16 90 | $\frac{1}{2}$ | 61 1268 | 1347 | 0458 | 18 92 |
| $\frac{1}{2}$ | 75 0031 | 0159 | 0481 | 21 79 | $\frac{1}{2}$ | 59 7626 | 7719 | 0355 | 14 55 |
| $\frac{1}{2}$ | 74 0754 | 0862 | 0444 | 20 02 | 1 | 58 4051 | 4151 | 0446 | 18 11 |
| 2 | 73 4156 | | | | $\frac{1}{2}$ | 52 0778 | 0920 | 0338 | 13 18 |
| 1 | 72 6808 | 6896 | 0450 | 20 07 | 2 | 49 9854 | | | |
| 2 | 71 7318 | 7410 | 0412 | 18 29 | 1 | 48 0966 | 1130 | 0463 | -17 59 |
| 2 | 68 6164 | | | | | | | | |

Weighted mean - 19 76
V_a + 25 02
V_d + 20
Curvature - 28

Radial velocity + 5 2

SESSIONAL PAPER No. 25a

 η BOÖTIS 2283.1909. Feb 17.
G. M. T. 20^h 30^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 76.7061 | | | | 1 | 61.0771 | .1522 | .0283 | 11.70 |
| $\frac{1}{2}$ | 76.6704 | .7317 | .0357 | 16.38 | 1 | 59.6981 | .7740 | .0324 | 13.27 |
| 1 | 74.9769 | .0382 | .0258 | 11.70 | 1 | 56.7141 | .7913 | .0342 | 13.74 |
| $\frac{1}{2}$ | 74.0486 | .1100 | .0206 | 9.28 | 2 | 56.2824 | | | |
| 1 | 73.0121 | .0736 | .0474 | 21.21 | $\frac{1}{2}$ | 52.9986 | .0808 | .0450 | 17.53 |
| 2 | 73.3628 | | | | $\frac{1}{2}$ | 51.6967 | .7801 | .0303 | 11.78 |
| 1 | 72.1104 | .1739 | .0272 | 12.10 | 1 $\frac{1}{2}$ | 49.8821 | .9680 | .0321 | 12.34 |
| 2 | 71.6891 | .7546 | .0276 | 12.24 | 1 $\frac{1}{2}$ | 48.0301 | .1171 | .0378 | 14.35 |
| 1 | 69.6231 | .6925 | .0217 | 9.49 | 2 | 46.3428 | | | |
| 2 | 68.5548 | | | | 1 | 46.2721 | .3617 | .0532 | 19.97 |
| 1 | 68.5298 | .6012 | .0265 | 11.51 | 2 | 33.0633 | | | |
| $\frac{1}{2}$ | 67.6224 | .6945 | .0224 | 9.67 | $\frac{1}{2}$ | 31.5776 | .6899 | .0444 | 15.19 |
| 2 | 63.2498 | | | | 1 | 30.8284 | .9422 | .0517 | 17.61 |
| 1 | 63.1931 | .2674 | .0421 | 17.65 | $\frac{1}{2}$ | 26.4908 | .6107 | .0496 | -16.44 |

Weighted mean - 13.98

 V_a + 20.25 V_d + .04

Curvature - 28

Radial velocity + 6.0

 η BOÖTIS 2396.1909. March 20.
G. M. T. 17^h 00^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 77.1341 | | | | 1 | 68.6049 | .6109 | .0168 | 7.29 |
| 1 | 76.7516 | .7463 | .0209 | -9.59 | 1 | 67.6992 | .7072 | .0097 | 4.19 |
| $\frac{1}{2}$ | 76.4234 | .4178 | .0960 | 2.75 | 2 | 61.3222 | | | |
| 1 | 75.0522 | .0491 | .0149 | 6.75 | 1 | 60.3016 | .3269 | .0113 | 4.64 |
| 1 | 74.1209 | .1191 | .0115 | 5.19 | 1 | 59.7754 | .8027 | .0037 | 1.51 |
| 2 | 73.4249 | | | | 1 | 58.4149 | .4462 | .0135 | 5.48 |
| 1 | 72.7076 | .7079 | .0267 | 11.91 | 2 | 49.9442 | | | |
| $\frac{1}{2}$ | 72.4306 | .4318 | .0157 | 7.00 | 1 | 49.9466 | .0041 | .0068 | 2.61 |
| 2 | 71.7664 | .7688 | .0134 | 5.95 | 2 | 30.9059 | | | |
| 2 | 71.1534 | | | | 1 | 30.8756 | .9795 | .0144 | -4.91 |
| 1 | 69.7034 | .7074 | .0068 | 2.97 | | | | | |

Weighted mean - 5.59

 V_a + 8.52 V_d + .14

Curvature - 28

Radial velocity + 2.8

9-10 EDWARD VII., A. 1910

OBSERVING RECORD AND DETAILED MEASURES OF α CORONÆ BOREALIS.

RECORD OF SPECTROGRAMS.

P.—PLASKETT.
 Pl.—PARKER.
 H.—HARPER.
 C.—CANNON.
 T.—TRIBBLE.

| STAR. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure G. M. T. | | Duration. | Hour Angle at end. | TEMPERATURE. Centigrade. | | | | Slit Width. | Seeing. | Observer |
|-----------------|------------------|---------|--------|---------|--------------------------------|----|-----------|--------------------------|-----------------------------|------|------------|------|-------------|------------------|----------|
| | | | | | | | | | Room. | | Prism Box. | | | | |
| | | | | | | | | | Beg. | End. | Beg. | End. | | | |
| | | | | 1907. | h. m. | m. | h. m. | | | | | | | | |
| α Coronæ | 784 | IL | Seed | 27. May | 24 17 | 43 | 10 1 | 20W. | 9 0 | 9 4 | 16 4 | 16 4 | 001 | Fair... | P |
| Borealis : | 790 | " | " | " | 29 15 | 14 | 12 | 50W. | 8 9 | 9 0 | 14 5 | 14 5 | 001 | " | P |
| " | 800 | " | " | " | 31 17 | 18 | 8 | 20W. | 13 0 | 12 8 | 18 8 | 18 8 | 001 | Good... | P |
| " | 808 | " | " | June | 8 16 | 28 | 10 1 | 05W. | 15 4 | 15 2 | 17 2 | 17 2 | 001 | " | P |
| " | 813 | " | " | " | 10 15 | 23 | 10 0 | 00 | 14 8 | 14 6 | 18 1 | 18 1 | 001 | " | P |
| " | 830 | " | " | " | 11 17 | 40 | 10 2 | 15W. | 14 0 | 14 0 | 18 9 | 18 9 | 001 | Fair... | H |
| " | 837a | " | " | " | 12 17 | 36 | 12 2 | 30W. | 17 0 | 16 3 | 19 0 | 19 0 | 001 | " | P |
| " | 837b | " | " | " | 12 17 | 52 | 12 2 | 42W. | 16 0 | 15 6 | 19 0 | 19 0 | 001 | " | P |
| " | 845 | " | " | " | 13 16 | 32 | 15 1 | 30W. | 19 8 | 19 4 | 25 8 | 25 8 | 0012 | " | H |
| " | 850a | " | " | " | 14 16 | 39 | 12 1 | 40W. | 21 6 | 21 4 | 23 3 | 23 3 | 0012 | " | P |
| " | 850b | " | " | " | 14 16 | 52 | 5 1 | 50W. | 21 4 | 21 1 | 23 3 | 23 3 | 0012 | Good... | P |
| " | 869a | " | " | " | 21 15 | 10 | 15 50W. | 24 8 | 24 8 | 28 9 | 28 9 | 001 | Hazy... | P | |
| " | 869b | " | " | " | 21 15 | 42 | 15 1 | 20W. | 24 8 | 24 6 | 28 9 | 29 0 | 001 | " | P |
| " | 892a | " | " | " | 27 15 | 25 | 10 1 | 17W. | 21 2 | 20 9 | 24 5 | 24 5 | 0012 | Fair... | H |
| " | 892b | " | " | " | 27 15 | 37 | 5 1 | 25W. | 20 9 | 20 9 | 24 5 | 24 5 | 0012 | Cloudy. | T |
| " | 903a | " | " | " | 28 14 | 36 | 13 33W. | 23 8 | 23 6 | 26 4 | 26 3 | 0012 | Fair... | P | |
| " | 903b | " | " | " | 28 14 | 57 | 25 1 | 00W. | 23 5 | 22 8 | 26 3 | 26 2 | 0012 | " | P |
| " | 912a | " | " | July | 4 15 | 38 | 10 2 | 00W. | 21 0 | 20 5 | 29 0 | 28 8 | 0012 | Good... | H |
| " | 912b | " | " | " | 4 15 | 47 | 5 2 | 17W. | 21 0 | 20 0 | 28 8 | 28 6 | 0012 | " | H |
| " | 917 | " | " | " | 5 15 | 20 | 10 1 | 45W. | 21 0 | 20 8 | 26 4 | 26 4 | 0011 | " | P |
| " | 919 | " | " | " | 8 15 | 36 | 22 2 | 05W. | 21 2 | 21 2 | 22 4 | 22 4 | 0012 | Fair... | P |
| " | 927 | " | " | " | 9 14 | 32 | 15 1 | 14W. | 23 1 | 23 1 | 24 5 | 24 5 | 0012 | Good... | H |
| " | 939a | " | " | " | 12 16 | 25 | 10 4 | 15W. | 22 6 | 22 4 | 26 0 | 26 0 | 0012 | " | P |
| " | 939b | " | " | " | 12 16 | 33 | 24 4 | 20W. | 22 6 | 22 4 | 26 0 | 26 0 | 0012 | " | P |
| " | 941a | " | " | " | 13 15 | 25 | 10 3 | 15W. | 18 2 | 18 0 | 25 2 | 25 0 | 0012 | " | T |
| " | 941b | " | " | " | 13 15 | 32 | 3 3 | 20W. | 18 0 | 17 8 | 21 0 | 25 0 | 0012 | " | T |
| " | 944a | " | " | " | 16 14 | 37 | 13 1 | 42W. | 25 5 | 25 5 | 26 8 | 26 8 | 0012 | Unst'dy | T |
| " | 944b | " | " | " | 16 14 | 49 | 6 1 | 53W. | 25 5 | 25 5 | 26 8 | 26 8 | 0012 | " | T |
| " | 951a | " | " | " | 18 14 | 50 | 60 2 | 32W. | 26 0 | 25 0 | 28 5 | 28 5 | 0012 | Very hazy.. | T |
| " | 951b | " | " | " | 18 15 | 32 | 5 2 | 45W. | 22 5 | 22 5 | 28 5 | 28 5 | 0012 | " | H |
| " | 956a | " | " | " | 20 16 | 07 | 14 3 | 30W. | 19 2 | 18 6 | 21 6 | 21 6 | 0012 | Good... | P |
| " | 956b | " | " | " | 20 16 | 17 | 2 3 | 32W. | 19 2 | 18 6 | 21 6 | 21 6 | 0012 | " | P |
| " | 963a | " | " | " | 23 14 | 32 | 6 2 | 05W. | 23 2 | 23 2 | 26 4 | 26 4 | 0012 | " | T |
| " | 963b | " | " | " | 23 14 | 41 | 3 2 | 15W. | 22 6 | 22 6 | 26 4 | 26 4 | 0012 | " | T |
| " | 973a | " | " | Aug. | 1 14 | 06 | 12 2 | 15W. | 21 3 | 21 0 | 25 2 | 25 2 | 0008 | " | H |
| " | 973b | " | " | " | 1 14 | 18 | 8 2 | 26W. | 21 0 | 19 5 | 25 2 | 25 2 | 0008 | " | H |
| " | 978 | " | " | " | 3 13 | 02 | 8 1 | 15W. | 21 6 | 20 8 | 24 1 | 24 1 | 0012 | " | P |
| " | 986 | " | " | " | 6 16 | 38 | 23 5 | 15W. | 19 5 | 19 4 | 23 3 | 23 3 | 0012 | Poor... | H |
| " | 1006 | " | " | " | 12 16 | 36 | 12 5 | 31W. | 23 0 | 22 5 | 29 0 | 29 0 | 0014 | Unst'dy | H |
| " | 1014 | " | " | " | 15 15 | 09 | 7 4 | 20W. | 22 3 | 19 5 | 26 3 | 26 3 | 0014 | Very poor.. | H |
| " | 1017 | " | " | " | 22 15 | 11 | 11 4 | 47W. | 18 7 | 18 5 | 24 1 | 24 2 | 0014 | Fair... | H |
| " | 1022 | " | " | " | 23 14 | 46 | 62 4 | 46W. | 22 5 | 21 4 | 27 0 | 27 0 | 0014 | Light clouds. | T |
| " | 1026 | " | " | " | 27 12 | 06 | 13 2 | 57W. | 18 5 | 18 5 | 20 6 | 20 6 | 0014 | Fair... | T |
| " | 1032 | " | " | Sept. | 6 13 | 43 | 17 4 | 15W. | 19 0 | 18 5 | 21 0 | 21 0 | 0012 | Good... | T |
| " | 1037 | " | " | " | 12 14 | 39 | 18 5 | 37W. | 17 0 | 16 8 | 20 9 | 20 9 | 0012 | " | T |
| " | 1047 | " | " | " | 18 12 | 50 | 30 4 | 17W. | 15 0 | 15 0 | 17 1 | 17 1 | 0012 | Cloudy. | T |
| " | 1048 | " | " | " | 18 13 | 16 | 16 4 | 36W. | 15 0 | 14 2 | 17 1 | 17 1 | 0012 | Fair... | T |
| " | 1060 | " | " | " | 20 13 | 35 | 20 5 | 05W. | 22 0 | 22 0 | 22 9 | 22 9 | 0012 | Poor... | H |
| " | 1061 | " | " | " | 20 13 | 58 | 24 5 | 30W. | 22 0 | 22 3 | 22 9 | 22 9 | 0012 | " | H |
| " | 1083 | " | " | Oct. | 1 13 | 44 | 16 5 | 55W. | 10 5 | 10 4 | 14 2 | 14 2 | 0014 | " | H |
| " | 1084 | " | " | " | 1 14 | 06 | 27 6 | 23W. | 10 4 | 10 2 | 14 2 | 14 1 | 0014 | Hazy... | H |

SESSIONAL PAPER No. 25a

RECORD OF SPECTROGRAMS.—(Concluded).

| STAR. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure. G. M. T. | | Duration. | Hour Angle at end. | TEMPERATURE. Centigrade. | | | | Slit Width. | Seeing. | Observer. | |
|------------------|------------------|---------|---------|----------|---------------------------------|-------|-----------|--------------------------|-----------------------------|-------|------------|------|-------------|---------|----------------|----------------|
| | | | | | | | | | Room. | | Prism Box. | | | | | |
| | | | | | | | | | Beg. | End. | Beg. | End. | | | | |
| 1908. | | | | | h. m. | m. | h. m. | | | | | | | | | |
| α Coronae | 1333 | 1L | Seed | 27. Mar. | 9 22 | 08 | 24 | 55W. | -15 0 | -15 0 | 1 0 | 1 0 | | Hazy | H | |
| Borealis: | 1402 | " | " | " | 16 21 | 02 | 19 | 9W. | -12 5 | -13 0 | 2 3 | 2 3 | | Good | H | |
| " | 1493 | " | " | Apr. | 15 19 | 18 | 8 | 28W. | -3 0 | -2 3 | 7 8 | 7 7 | | " | P | |
| " | 1565 | " | Seed | June | 1 18 | 00 | 30 | 50W. | 15 7 | 14 6 | 21 4 | 21 3 | | " | P ₁ | |
| " | 1566 | " | Process | " | 1 18 | 42 | 15 | 3 13W. | 14 5 | 14 0 | 21 3 | 21 2 | | Fair | P ₁ | |
| " | 1571 | " | Seed | 27. | " | 3 16 | 32 | 15 | 3 57W. | 14 9 | 15 0 | 18 4 | 18 4 | | " | P |
| " | 1572 | " | " | " | " | 3 16 | 52 | 15 | 1 20W. | 15 0 | 14 8 | 18 4 | 18 4 | | " | P |
| " | 1581 | " | " | " | " | 5 17 | 31 | 18 | 2 04W. | 17 5 | 17 0 | 24 6 | 24 6 | 0016 | Good | H |
| " | 1601 | " | " | " | " | 12 16 | 56 | 12 | 1 54W. | 19 5 | 19 6 | 25 0 | 25 0 | 0017 | " | H |
| " | 1608 | " | " | " | " | 17 13 | 53 | 14 | 50E. | 19 0 | 18 5 | 23 4 | 23 3 | 0016 | " | H |
| " | 1623 | " | " | " | " | 22 16 | 27 | 14 | 2 10W. | 18 3 | 18 0 | 23 7 | 23 8 | 0015 | Fair | P |
| " | 1624 | " | " | " | " | 22 16 | 43 | 13 | 2 25W. | 18 0 | 18 0 | 23 8 | 23 8 | 0015 | Good | P |
| " | 1628 | " | " | " | " | 24 15 | 26 | 18 | 1 15W. | 21 5 | 21 5 | 27 5 | 27 5 | 0015 | " | P |
| " | 1629 | " | " | " | " | 24 15 | 49 | 15 | 1 35W. | 21 5 | 21 5 | 27 5 | 27 5 | 0015 | " | P |
| " | 1638 | " | " | " | " | 26 15 | 51 | 15 | 1 48W. | 21 0 | 20 5 | 30 0 | 30 0 | 0016 | " | H |
| " | 1639 | " | " | " | " | 26 16 | 04 | 8 | 1 57W. | 20 5 | 21 0 | 30 0 | 30 0 | 0016 | " | H |
| " | 1646 | " | " | " | " | 27 16 | 20 | 10 | 2 20W. | 20 8 | 20 5 | 23 8 | 23 8 | 0014 | " | P |
| " | 1647 | " | " | " | " | 27 16 | 30 | 10 | 2 30W. | 20 5 | " | " | " | Fair | P | |
| " | 1652 | " | " | July | " | 1 15 | 15 | 30 | 1 30W. | 23 6 | 23 6 | 25 8 | 25 8 | 0015 | Cloudy | P |
| " | 1656 | " | " | " | " | 3 15 | 17 | 13 | 1 38W. | 23 0 | 21 9 | 25 5 | 25 5 | 001 | Good | H |
| " | 1665 | " | " | " | " | 6 16 | 50 | 10 | 3 20W. | 24 0 | 23 8 | 26 4 | 26 4 | 0015 | " | P |
| " | 1674 | " | " | " | " | 8 15 | 11 | 10 | 1 50W. | 19 0 | 19 3 | 21 8 | 21 8 | 0015 | Fair | C |
| " | 1683 | " | " | " | " | 10 13 | 34 | 20 | 26W. | 25 0 | 24 5 | 27 5 | 27 5 | 0012 | Good | H |
| " | 1684 | " | " | " | " | 10 13 | 51 | 13 | 40W. | 24 5 | 24 5 | 27 5 | 27 5 | 0012 | " | H |
| " | 1692 | " | " | " | " | 11 16 | 29 | 10 | 3 12W. | 27 7 | 27 5 | 30 1 | 30 1 | 0015 | Fair | P |
| " | 1697 | " | " | " | " | 13 15 | 26 | 13 | 2 25W. | 20 0 | 19 9 | 23 1 | 23 1 | 0015 | " | P |
| " | 1698 | " | " | " | " | 13 15 | 42 | 16 | 2 50W. | 19 9 | 19 6 | 23 1 | 23 1 | 0015 | " | P |
| " | 1711 | " | " | " | " | 15 16 | 24 | 12 | 3 30W. | 17 5 | 17 0 | 21 6 | 21 6 | 0015 | Good | C |
| " | 1721 | " | " | " | " | 24 13 | 05 | 15 | 48W. | 24 0 | 24 0 | 26 4 | 26 4 | 0012 | " | H |
| " | 1722 | " | " | " | " | 24 13 | 21 | 14 | 1 03W. | 24 0 | 24 0 | 26 4 | 26 4 | 0012 | " | H |
| " | 1739 | " | " | " | " | 29 15 | 34 | 12 | 3 37W. | 26 6 | 26 3 | 30 2 | 30 2 | 0015 | Fair | P |
| " | 1748 | " | " | " | " | 31 13 | 38 | 17 | 2 00W. | 23 3 | 23 1 | 26 0 | 26 0 | 0015 | " | P ₁ |
| " | 1749 | " | " | " | " | 31 14 | 00 | 20 | 2 20W. | 23 0 | 22 6 | 26 0 | 26 0 | 0015 | " | P |
| " | 1764 | " | " | Aug. | " | 5 15 | 37 | 15 | 4 10W. | 22 0 | 21 6 | 26 9 | 26 9 | 0015 | " | P |
| " | 1773 | " | " | " | " | 7 14 | 25 | 20 | 3 05W. | 21 5 | 20 6 | 23 6 | 23 6 | 0015 | Hazy | P ₁ |
| " | 1775 | " | " | " | " | 7 16 | 25 | 10 | 5 05W. | 19 1 | 19 0 | 23 6 | 23 6 | 0015 | Good | P ₁ |
| " | 1797 | " | " | " | " | 20 12 | 51 | 16 | 2 21W. | 19 2 | 19 0 | 23 1 | 23 1 | 0015 | Fair | H |
| " | 1798 | " | " | " | " | 20 13 | 05 | 10 | 2 32W. | 19 0 | 18 8 | 23 1 | 23 0 | 0015 | Good | H |
| " | 1805 | " | " | " | " | 21 12 | 54 | 11 | 2 22W. | 21 1 | 20 6 | 25 8 | 25 8 | 0015 | " | C |
| " | 1809 | " | " | " | " | 21 15 | 01 | 12 | 4 30W. | 18 8 | 18 4 | 25 0 | 25 4 | 0015 | " | C |
| " | 1816 | " | " | " | " | 24 13 | 17 | 15 | 3 03W. | 18 5 | 18 2 | 23 4 | 23 4 | 0015 | " | H |
| " | 1817 | " | " | " | " | 24 13 | 32 | 14 | 3 17W. | 18 2 | 17 5 | 23 4 | 23 3 | 0015 | " | H |
| " | 1827 | " | " | " | " | 25 13 | 00 | 14 | 2 49W. | 20 6 | 19 3 | 26 0 | 26 0 | 0015 | Hazy | C |
| " | 1836 | " | " | " | " | 27 14 | 34 | 12 | 4 30W. | 18 3 | 18 0 | 23 2 | 23 2 | 0015 | Good | C |
| " | 1842 | " | " | " | " | 28 13 | 14 | 12 | 3 16W. | 18 5 | 18 2 | 23 3 | 23 3 | 0015 | " | C |
| " | 1852 | " | " | " | " | 31 13 | 17 | 15 | 3 30W. | 24 0 | 24 0 | 28 0 | 28 0 | 0015 | " | H |
| " | 1861 | " | " | Sept. | " | 3 12 | 50 | 13 | 3 15W. | 18 6 | 18 8 | 21 2 | 21 1 | 0015 | " | P |
| " | 1865 | " | " | " | " | 4 13 | 27 | 26 | 4 05W. | 20 5 | 20 3 | 23 4 | 23 4 | 0015 | Poor | P ₁ |
| " | 1882 | " | " | " | " | 14 12 | 51 | 13 | 4 00W. | 18 6 | 18 4 | 21 7 | 21 7 | 0015 | Fair | P |
| " | 1894 | " | " | " | " | 19 12 | 02 | 13 | 3 30W. | 17 5 | 17 3 | 21 2 | 21 2 | 0015 | " | P |
| " | 1895 | " | " | " | " | 19 12 | 17 | 15 | 3 45W. | 17 3 | 17 2 | 21 2 | 21 2 | 0015 | " | P |
| " | 1896 | " | " | " | " | 19 12 | 32 | 15 | 4 00W. | 17 2 | 16 8 | 21 1 | 21 1 | 0015 | " | P |
| " | 1897 | " | " | " | " | 19 12 | 50 | 16 | 4 20W. | 16 8 | 16 5 | 21 1 | 21 0 | 0015 | " | P |
| " | 1949 | " | " | Nov. | " | 1 10 | 41 | 17 | 5 00W. | 2 0 | 0 6 | 3 8 | 3 8 | 0015 | Good | C |
| " | 1991 | " | " | Dec. | " | 2 10 | 10 | 10 | 6 19W. | -7 5 | -8 2 | -2 0 | -2 0 | 0015 | Windy | C |
| " | 1992 | " | " | " | " | 2 10 | 21 | 13 | 6 30W. | -8 2 | -8 2 | -2 0 | -2 0 | 0015 | " | C |

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 784.1907. May 24.
G. M. T. 17^h 43^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 12 | 72.9951 | 4891.192 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.6301 | 4105.162 | ..... | ..... | ..... | ..... |
| 12 | 72.7321 | 4861.180 | .187 | .527 | .340 | -21.00 | 1 | 27.3080 | 4101.318 | .440 | .890 | .430 | -32.90 |
| 12 | 72.3165 | 4851.453 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.1825 | 4099.824 | ..... | ..... | ..... | ..... |
| 12 | 47.6461 | 4379.418 | ..... | ..... | ..... | ..... | 2 | 15.4180 | 3969.627 | .807 | .177 | .670 | -50.77 |
| 12 | 45.0940 | 4340.085 | .054 | .634 | .580 | -40.02 | 3 | 15.3605 | 3969.034 | ..... | ..... | ..... | ..... |
| 12 | 44.1555 | 4325.981 | ..... | ..... | ..... | ..... | 3 | 28.1875 | 4111.853 | ..... | ..... | ..... | ..... |

Weighted mean -32.78
 V_a -7.63
 V_d 07
 Curvature -28

Radial velocity -39.8

 α CORONÆ BOREALIS, 790.1907. May 25.
G. M. T. 15^h 14^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 12 | 73.2093 | 4870.229 | ..... | ..... | ..... | ..... | 2 | 27.7347 | 4105.312 | ..... | ..... | ..... | ..... |
| 12 | 72.8135 | 4800.908 | 2.167 | 1.527 | .580 | +35.78 | 1 $\frac{1}{2}$ | 27.5259 | 4102.815 | .700 | 1.890 | .810 | +59.21 |
| 12 | 63.6051 | 4661.138 | ..... | ..... | ..... | ..... | 3 | 27.2873 | 4099.970 | ..... | ..... | ..... | ..... |
| 12 | 48.7335 | 4395.316 | ..... | ..... | ..... | ..... | 3 | 15.64— | 3970.820 | .797 | .177 | .620 | +47.00 |
| 12 | 45.2535 | 4341.252 | ..... | ..... | ..... | ..... | 3 | 15.4860 | 3969.232 | ..... | ..... | ..... | ..... |
| 12 | 45.2502 | 4341.201 | .114 | 0.634 | .480 | +33.12 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Weighted mean +41.68
 V_a -9.22
 V_d -10
 Curvature -28

Radial velocity +32.3

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 794.1907. May 29.
G. M. T. 18^h 05^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 12 | 72 8775 | 4862 407 | 407 | 1 527 | 880 | +59 30 | 1 | 27 5506 | 4102 369 | 360 | 1 890 | 470 | +34 36 |
| 11 | 63 6559 | 4661 600 | | | | | 1/2 | 12 111 - | 3934 713 | 795 | 3 825 | 970 | +74 01 |
| 2 | 45 3234 | 4341 403 | 388 | 0 634 | 754 | +52 02 | 3 | 11 6613 | 3930 276 | | | | |
| | 45 3085 | 4341 177 | | | | | | | | | | | |
| | 27 7905 | 4105 235 | | | | | | | | | | | |

Weighted mean. +53 45

 V_a - 9 22 V_d 14

Curvature. 28

Radial velocity +43 8

 α CORONÆ BOREALIS, 860.1907. May 31.
G. M. T. 17^h 18^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| | 73 2965 | 4871 490 | | | | | 11 | 45 3314 | 4341 634 | 1 000 | 0 634 | 366 | +25 25 |
| | 72 8966 | 4862 058 | 2 021 | 1 527 | 494 | +30 48 | 1/2 | 45 3203 | 4341 463 | | | | |
| 1 | 63 6950 | 4662 143 | | | | | | | | | | | |

Weighted mean. +28 24

 V_a - 9 87 V_d 09

Curvature. 28

Radial velocity -18 00

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α CORONÆ BOREALIS, 800*.

1907. May 31.
G. M. T. 17^h 18^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|-----|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-------------------------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 73·1662 | 4870·711 | ..... | ..... | ..... | ..... | 1 ³ / ₄ | 53·9228 | 4482·746 | ·156 | ·400 | ·756 | + [50·57] |
| 2 | 72·7643 | 4861·253 | ·993 | ·527 | ·366 | +22·58 | 1 ³ / ₄ | 45·1975 | 4341·903 | ..... | ..... | ..... | ..... |
| 1 | 53·9370 | 4482·990 | ..... | ..... | ..... | ..... | 2 | 45·1921 | 4341·822 | ·084 | ·634 | ·450 | +31·05 |

Weighted mean. +26·82

V_a -9·87V_d ·09

Curvature. ·28

Radial velocity. +16·6

*Check measurement.

α CORONÆ BOREALIS, 808.

1907. June 8.
G. M. T. 16^h 28^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|-------------------------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-------------------------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 2 | 73·6301 | 4880·622 | ..... | ..... | ..... | ..... | 1 ³ / ₄ | 53·2825 | 4459·560 | ..... | ..... | ..... | ..... |
| 1 ³ / ₄ | 73·2099 | 4870·635 | ..... | ..... | ..... | ..... | 1 ³ / ₄ | 45·2977 | 4341·340 | ..... | ..... | ..... | ..... |
| 2 | 72·7779 | 4860·446 | ·117 | ·527 | ·410 | -25·30 | 1 ³ / ₄ | 45·2356 | 4340·399 | ·224 | ·634 | ·410 | -28·29 |
| 1 ³ / ₄ | 54·7247 | 4494·835 | ..... | ..... | ..... | ..... | 2 | 27·4985 | 4101·465 | ·740 | ·890 | ·150 | -10·97 |
| 1 | 53·9597 | 4481·558 | ·400 | ·400 | ·000 | [0·00] | 2 | 27·3464 | 4099·648 | ..... | ..... | ..... | ..... |

Weighted mean. -24·63

V_a -12·26V_d ·07

Curvature ·28

Radial velocity -37·2

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 813.1907, June 10.
G. M. T. 15^h 23^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| W _t . | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | W _t . | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|------------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|------------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 1 | 72·9500 | 4864·729 | | | | | 1 $\frac{1}{2}$ | 45·2570 | 4340·581 | 584 | 631 | 050 | - 3·45 |
| 2 | 72·7916 | 4860·995 | 047 | 527 | 480 | -29·62 | 1 $\frac{1}{2}$ | 27·4836 | 4101·565 | 565 | 800 | 325 | -23·76 |
| 3 | 54·0328 | 4482·605 | | | | | 3 | 11·9745 | 3933·225 | 505 | 826 | 320 | -23·52 |
| 1 $\frac{1}{2}$ | 53·9933 | 4481·933 | 720 | 400 | 320 | + (21·40) | 3 | 11·6547 | 3930·072 | | | | |

Weighted mean..... -19·99

V_a..... 12·82V_d..... 00

Curvature..... -28

Radial velocity..... -33·1

 α CORONÆ BOREALIS, 813*.1907 June 10.
G. M. T. 15^h 23^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| W _t . | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | W _t . | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|------------------|-------------------|--------------------------|------------------------------|-----------|------------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73·0019 | | | | 1 | 27·4611 | 3746 | 0380 | - 33·00 |
| 1 | 72·8452 | 8543 | 0105 | - 15·23 | 2 | 27·3334 | | | |
| 1 | 72·4360 | | | | 3 | 11·9831 | 8494 | 0020 | - 1·50 |
| 2 | 45·2832 | | | | 2 $\frac{1}{2}$ | 11·6415 | | | |
| 1 $\frac{1}{2}$ | 45·2550 | 2404 | 0017 | + 1·77 | | | | | |

Weighted mean..... -11·33

V_a..... -12·82V_d..... 00

Curvature..... -28

Radial velocity..... - 23·4

Check measurement.

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 830.1907. June 11.
G. M. T. 17^h 40^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| $\frac{1}{2}$ | 73.0400 | ..... | ..... | ..... | 1 | 27.5388 | .4018 | .0108 | - 9.37 |
| $\frac{1}{2}$ | 72.9005 | .8714 | .0066 | + 9.57 | 2 | 27.3838 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.4707 | ..... | ..... | ..... | $\frac{1}{2}$ | 15.6378 | .4462 | .0271 | -20.97 |
| $\frac{1}{4}$ | 45.3505 | ..... | ..... | ..... | $\frac{1}{2}$ | 15.5903 | ..... | ..... | ..... |
| $\frac{1}{4}$ | 45.2871 | .2202 | .0177 | -19.31 | | | | | |

Weighted mean -12.59
 V_d -13.12
 V_d -14
 Curvature -28

Radial velocity -26.1

 α CORONÆ BOREALIS, 837 (a).1907. June 12.
G. M. T. 17^h 36^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. |
|---------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|---------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| $\frac{1}{2}$ | 73.2575 | 4871.377 | ..... | ..... | ..... | ..... | $\frac{1}{4}$ | 53.2836 | 4469.109 | .260 | 1.400 | .140 | - 9.37 |
| $\frac{1}{2}$ | 72.9550 | 4864.316 | ..... | ..... | ..... | ..... | $\frac{1}{2}$ | 45.2743 | 4341.034 | ..... | ..... | ..... | ..... |
| 1 | 72.7939 | 4860.427 | .027 | .527 | .500 | -30.85 | $\frac{1}{2}$ | 45.2468 | 4340.618 | .744 | .634 | .110 | + 7.50 |
| $\frac{1}{4}$ | 54.7243 | 4494.565 | ..... | ..... | ..... | ..... | 1 | 27.4500 | 4101.723 | .700 | .890 | .190 | -13.40 |
| 1 | 54.0416 | 4482.729 | .880 | 1.400 | 1480 | +39.01 | $\frac{1}{2}$ | 27.2997 | 4069.937 | ..... | ..... | ..... | ..... |
| $\frac{1}{4}$ | 53.9476 | 4484.109 | ..... | ..... | ..... | ..... |  |  |  |  |  |  |  |

Weighted mean - 7.84
 V_d -13.39
 V_d -15
 Curvature -28

Radial velocity -21.7

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 837 (b).1907. June 12.
G. M. T. 17^h 48^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. |
|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 3 | 73.3641 | 4871.496 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 45.3637 | 4340.923 | .834 | .634 | .200 | +13.80 |
| 1 $\frac{1}{2}$ | 73.0748 | 4864.652 | ..... | ..... | ..... | ..... | 1 | 27.5769 | 4102.126 | .780 | .890 | .110 | - 8.74 |
| 1 $\frac{1}{2}$ | 72.9262 | 4861.152 | ..... | ..... | ..... | ..... | 3 | 27.4205 | 4100.265 | ..... | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 45.3955 | 4341.251 | .417 | .527 | .080 | + 4.90 | | | | | | | |

Weighted mean..... + 2.22

 V_a -13.39 V_d - 15

Curvature..... - 23

Radial velocity..... - 11.6

 α CORONÆ BOREALIS, 845.1907. June 13.
G. M. T. 16^h 32^mObserved by
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 3 | 73.5911 | 4875.434 | ..... | ..... | ..... | ..... | 3 | 30.3756 | 4135.609 | .374 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 73.1412 | 4864.776 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 30.3142 | 4134.852 | ..... | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 73.0219 | 4861.964 | .817 | .527 | .290 | +17.89 | 1 | 27.6096 | 4102.126 | 1.921 | .890 | .631 | + 2.27 |
| 1 $\frac{1}{2}$ | 45.4418 | 4341.360 | ..... | ..... | ..... | ..... | 3 | 27.4418 | 4100.132 | ..... | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 45.4224 | 4341.068 | 0.868 | .634 | .234 | +16.14 | | | | | | | |

Weighted mean..... +12.68

 V_a -13.65 V_d - 10

Curvature..... - 23

Radial velocity..... - 1.4

9-10 EDWARD VII., A. 1910

a CORONÆ BOREALIS, 850 (a).

1907. June 14.
G. M. T. 16^h 39^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| W _L | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | W _L | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|----------------|-------------------------|-----------------------------|---------------------------|------------------------|---------------------------------|-----------|----------------|-------------------------|-----------------------------|---------------------------|------------------------|---------------------------------|-----------|
| 12 | 73·4113 | 4875·633 | ..... | ..... | ..... | ..... | 12 | 53·9875 | 4482·586 | 1·046 | ·400 | ·646 | +43·22 |
| 12 | 72·9635 | 4865·037 | ..... | ..... | ..... | ..... | 12 | 53·2781 | 4470·405 | ..... | ..... | ..... | ..... |
| 1 | 72·8279 | 4861·845 | ·747 | ·527 | ·220 | +13·57 | 2 | 45·2668 | 4341·590 | ..... | ..... | ..... | ..... |
| 12 | 54·3973 | 4489·656 | ..... | ..... | ..... | ..... | 2 | 45·2482 | 4341·307 | 0·879 | ·634 | ·245 | +16·90 |

Weighted mean +15·79

V_a -13·92V_d ·12

Curvature ·28

Radial velocity .. +1·5

a CORONÆ BOREALIS, 850 (b).

1907. June 14.
G. M. T. 16^h 52^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| W _L | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. | W _L | Mean of Settings. | Computed Wave Length. | Corrected wave length. | Normal wave length. | Displacement in revolutions. | Velocity. |
|----------------|-------------------------|-----------------------------|---------------------------|------------------------|---------------------------------|-----------|----------------|-------------------------|-----------------------------|---------------------------|------------------------|---------------------------------|-----------|
| 12 | 73·4199 | 4875·835 | ..... | ..... | ..... | ..... | 2 | 45·2684 | 4341·613 | ·188 | ·634 | ·554 | +38·23 |
| 12 | 72·9631 | 4865·169 | ..... | ..... | ..... | ..... | 1 | 27·4757 | 4102·322 | 2·290 | 1·890 | ·400 | +29·24 |
| 1 | 72·8446 | 4862·238 | 1·997 | ·527 | ·470 | +29·00 | 2 | 27·2770 | 4099·954 | ..... | ..... | ..... | ..... |
| 2 | 45·2666 | 4341·587 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Weighted mean +33·68

V_a -13·92V_d ·12

Curvature ·28

Radial velocity +19·4

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS. 861 (α).1907. June 20.
G. M. T. 16^h 05^mObserved by)
Measured by) W. E. HARPER.

| Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. | Wt. | Mean of Settings. | Computed Wave Length. | Corrected Wave Length. | Normal Wave Length. | Displacement in revolutions. | Velocity. |
|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|-----------------|-------------------|-----------------------|------------------------|---------------------|------------------------------|-----------|
| 1 | 73.2760 | 4871.450 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 45.2526 | 4341.493 | ..... | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 72.9905 | 4864.720 | ..... | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 45.2364 | 4341.249 | 0.918 | 0.634 | .284 | +19.60 |
| 1 | 72.8861 | 4862.267 | 2.467 | 1.527 | .940 | +58.00 | 1 | 27.4436 | 4102.363 | 2.320 | 1.890 | .430 | +31.43 |
| 54 | 0.070 | 4482.788 | 2.495 | 1.400 | 1.095 | +73.25 | 1 $\frac{1}{2}$ | 27.2416 | 4099.960 | ..... | ..... | ..... | ..... |
| 53 | 2695 | 4470.164 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Weighted mean..... +33.95

 V_a -15.42 V_d11

Curvature..... - .28

Radial velocity..... +17.1

 α CORONÆ BOREALIS, 869 (α).1907. June 21.
G. M. T. 15^h 10^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.4558 | ..... | ..... | ..... | 1 | 53.1220 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 72.9987 | ..... | ..... | ..... | 2 | 45.2828 | ..... | ..... | ..... |
| 1 | 72.8723 | .8833 | .0185 | +26.84 | 2 | 45.2626 | .2574 | .0187 | +19.52 |
| 1 | 72.4343 | ..... | ..... | ..... | 1 | 27.4687 | .4329 | .0203 | +17.62 |
| 1 $\frac{1}{2}$ | 54.7447 | ..... | ..... | ..... | 2 | 27.2824 | ..... | ..... | ..... |
| 54 | 0.017 | .9062 | .0264 | +30.39 | ..... | ..... | ..... | ..... | ..... |

Weighted mean..... +20.88

 V_a -15.65 V_d05

Curvature..... - .28

Radial velocity..... +4.9

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 869 (b).1907, June 21.
G. M. T. 15^h 42^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.4265 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 53.0887 | ..... | ..... | ..... |
| 1 $\frac{1}{2}$ | 72.9753 | ..... | ..... | ..... | 2 | 45.2563 | ..... | ..... | ..... |
| 1 | 72.8572 | .8940 | .0292 | +42.37 | 2 | 45.2497 | .2670 | .0283 | +29.53 |
| 1 | 72.4075 | ..... | ..... | ..... | 1 | 27.4248 | .4145 | .0019 | +1.65 |
| 2 | 54.7245 | ..... | ..... | ..... | 2 | 27.2569 | ..... | ..... | ..... |
| 1 | 54.0007 | .0197 | .0499 | +57.42 | | | | | |

Weighted mean..... -29.22

 V_a -15.66 V_d07

Curvature..... .28

Radial velocity..... +13.2

 α CORONÆ BOREALIS, 880.1907, June 25.
G. M. T. 15^h 43^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 49.3450 | ..... | ..... | ..... | 1 $\frac{1}{2}$ | 27.4294 | .4144 | .0018 | +1.50 |
| 2 | 45.1892 | .2092 | .0295 | -30.80 | 1 | 27.2616 | ..... | ..... | ..... |
| 2 | 44.2398 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... -24.34

 V_a -16.56 V_d10

Curvature..... .28

Radial velocity..... -41.3

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 888.1907. June 26.
G. M. T. 15^h 01^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 48.7894 | | | | $\frac{1}{2}$ | 27.5130 | 5033 | .0168 | +13.57 |
| 2 | 45.2958 | 2794 | .0307 | +32.14 | 1 | 27.3316 | | | |
| 2 | 45.2880 | | | | | | | | |

Weighted mean -28.42

 V_d -18.76 V_d 05

Curvature28

Radial velocity +11.3

 α CORONÆ BOREALIS, 892 (α).1907. June 27.
G. M. T. 15^h 25^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.9825 | | | | 2 | 45.2750 | | | |
| 1 | 72.8545 | .8822 | .0174 | +25.20 | $\frac{1}{2}$ | 45.2277 | .2363 | .0124 | -12.98 |
| 2 | 72.4160 | | | | 2 | 57.8430 | .8237 | .0190 | +(22.91)* |
| $\frac{1}{2}$ | 54.0205 | | | | $1\frac{1}{2}$ | 57.8172 | | | |
| $\frac{1}{4}$ | 53.9655 | .9603 | .0037 | + [4.27] | | | | | |

Weighted mean +12.47

 V_d -16.98 V_d 09

Curvature28

Radial velocity -4.9

*Not used.

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 892 (*b*).1907, June 27.
G. M. T. 15^h 25^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73·0205 | | | | 2 | 54·7740 | | | |
| 1 | 72·8582 | 8479 | ·0169 | -24·52 | 1 | 54·0162 | ·9814 | ·0116 | + [13·35] |
| 2 | 72·4540 | | | | 2 | 53·1495 | | | |
| 2 | 57·8550 | | | | 2 | 45·3208 | | | |
| 1 | 57·8570 | 8288 | ·0020 | + (2·41)* | 1 | 45·2668 | 2196 | ·0191 | -19·94 |

Weighted mean..... -21·47

 V_a -16·98 V_d -·09

Curvature..... -·28

Radial velocity..... -38·8

*Not used.

 α CORONÆ BOREALIS, 912 (*a*).1907, July 4.
G. M. T. 15^h 38^mObserved by W. E. HARPER.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73·4621 | | | | 3 | 54·0285 | ·0243 | ·0545 | + [62·73] |
| 1 | 73·0125 | | | | 2 | 53·1130 | | | |
| 1 | 72·8823 | 8823 | ·0175 | -25·39 | 2 | 45·2818 | | | |
| 1 | 72·4306 | | | | 1½ | 45·2930 | ·2843 | ·0461 | +48·13 |
| 1½ | 54·7496 | | | | | | | | |

Weighted mean..... +43·58

 V_a -18·30 V_d -·14

Curvature..... -·28

Radial velocity..... -24·5

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 917 (*a*).1907. July 5.
G. M. T. 15^h 20^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9847 | ..... | ..... | ..... | 2 | 53.1159 | ..... | ..... | ..... |
| 1 | 72.8795 | .9040 | .0392 | +56.38 | 2 | 45.2826 | ..... | ..... | ..... |
| 1½ | 72.4219 | ..... | ..... | ..... | 2 | 45.2955 | .2865 | .0478 | +49.90 |
| 2 | 54.7410 | ..... | ..... | ..... | ½ | 27.4935 | .4460 | .0334 | +28.99 |
| ¼ | 54.022 | .0210 | .0512 | +58.93 | 2 | 27.2942 | ..... | ..... | ..... |

Weighted mean. +48.77

 V_d -18.45 V_d -10

Curvature. -28

Radial velocity. +29.9

 α CORONÆ BOREALIS, 919.1907. July 8.
G. M. T. 15^h 36^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9772 | ..... | ..... | ..... | 1½ | 45.2712 | .2697 | .0210 | +21.98 |
| 1 | 72.8492 | .8372 | .0185 | +26.88 | 1 | 27.5298 | .5265 | .0300 | +34.16 |
| 2 | 72.4058 | ..... | ..... | ..... | 1 | 30.9330 | ..... | ..... | ..... |
| 2 | 45.2852 | ..... | ..... | ..... | 2 | 27.3256 | ..... | ..... | ..... |

Weighted mean. +26.86

 V_d -18.95 V_d -14

Curvature. -28

Radial velocity. +7.5

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 927.1907, July 9.
G. M. T. 14^h 32^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|------------|
| 2 | 72.9662 | | | | 2 | 45.2862 | | | |
| 1 | 72.8618 | .8562 | .0375 | +54.48 | 1½ | 45.2380 | 2354 | .0133 | -13.92 |
| 2 | 72.4106 | | | | ½ | 27.4734 | 4889 | .0076 | +1.40 |
| 2 | 54.7306 | | | | 2 | 27.3064 | | | |
| 1 | 53.9888 | .9833 | .0267 | + [30.81] | ½ | 57.8628 | .8428 | .0428 | + (51.62)* |
| 2 | 53.1078 | | | | 2 | 57.8178 | | | |

Weighted mean... -11.43

 V_a ... -19.09 V_d08

Curvature... .28

Radial velocity... -8.0

*Not used.

 α CORONÆ BOREALIS, 927.**1907, July 9.
G. M. T. 14^h 32^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|------------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9680 | | | | 1 | 53.9622 | 9697 | .0131 | + [15.12] |
| 1 | 72.8569 | .8503 | .0316 | +45.91 | 1½ | 53.0917 | | | |
| 1½ | 72.4102 | | | | 2 | 45.2603 | | | |
| ½ | 57.8736 | .8075 | .0675 | + (81.27)* | 1½ | 45.2267 | 2500 | .0013 | +1.36 |
| 1½ | 57.8040 | | | | ½ | 27.4465 | 4910 | .0055 | +3.20 |
| 2 | 54.7205 | | | | 3 | 27.2774 | | | |

Weighted mean... +16.52

 V_a ... -19.09 V_d08

Curvature... .28

Radial velocity... -2.9

**Check measurement.

*Not used.

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 936.1907, July 10.
G. M. T. 14^h 06^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|----------|
| 2 | 73.4385 | ..... | ..... | ..... | 2 | 45.3045 | .2916 | } mean .0317 | + 33.18 |
| 2 | 72.9873 | ..... | ..... | ..... | 2 | 45.2722 | .2693 | | |
| 1 | 72.8610 | 8370 | .0183 | + 25.58 | 1 | 27.4904 | .5206 | | |
| 2 | 45.2865 | ..... | ..... | ..... | 2 | 27.2917 | ..... | .0241 | + 28.99 |

Weighted mean..... + 30.48

 V_a - 19.23 V_d05

Curvature..... .28

Radial velocity..... + 10.9

 α CORONÆ BOREALIS, 936*1907, July 10.
G. M. T. 14^h 06^mObserved by J. S. PLASKETT.
Measured by J. E. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0197 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.5361 | 4419 | .0293 | + 25.43 |
| $\frac{1}{2}$ | 72.8963 | 8854 | .0206 | + 29.89 | 2 | 27.3413 | ..... | ..... | ..... |
| 2 | 72.4588 | ..... | ..... | ..... | $\frac{1}{2}$ | 12.0294 | .9169 | .0655 | + 49.06 |
| 2 | 45.3296 | ..... | ..... | ..... | 2 | 11.6198 | ..... | ..... | ..... |
| 1 | 45.3064 | .2504 | .0117 | + 12.21 | | | | | |

Weighted mean..... + 25.76

 V_a - 19.23 V_d05

Curvature..... .28

Radial velocity..... + 6.2

*Check measurement.

 α CORONÆ BOREALIS, 939 (a).1907, July 12.
G. M. T. 16^h 25^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9412 | ..... | ..... | ..... | $1\frac{1}{2}$ | 45.2344 | .2304 | .0183 | - 19.16 |
| 1 | 72.7980 | 8200 | .0013 | + 1.89 | 1 | 27.4394 | .4837 | .0035 | - 3.16 |
| 2 | 72.3774 | ..... | ..... | ..... | 2 | 27.2776 | ..... | ..... | ..... |
| 2 | 45.2876 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... - 8.58

 V_a - 19.52 V_d23

Curvature..... .28

Radial velocity..... - 28.6

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 941 (a).1907. July 13.
G. M. T. 15^h 25^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9571 | ..... | ..... | ..... | 1 | 53.9164 | .9216 | .0350 | - [36.52] |
| 1 | 72.7891 | .7967 | .0220 | - 31.94 | 2 | 45.2737 | ..... | ..... | ..... |
| 2 | 72.3883 | ..... | ..... | ..... | 2 | 45.2395 | .2494 | .0010 | + 1.05 |
| 1 | 54.0101 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... - 9.95

 V_a - 19.64 V_d - .20

Curvature..... - .28

Radial velocity..... - 30.1

 α CORONÆ BOREALIS, 944 (a).1907. July 16.
G. M. T. 14^h 37^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9844 | ..... | ..... | ..... | 2 | 45.2506 | .2292 | .0095 | - 9.94 |
| 1 | 72.8686 | .8938 | .0290 | + 42.08 | $\frac{1}{2}$ | 27.4712 | .4048 | .0078 | - 6.57 |
| 1 $\frac{1}{2}$ | 72.4200 | ..... | ..... | ..... | 2 | 27.3130 | ..... | ..... | ..... |
| 2 | 45.2950 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... - .20

 V_a - 19.98 V_d - .11

Curvature..... - .28

Radial velocity..... - 20.6

 α CORONÆ BOREALIS, 944 (a)*.1907. July 16.
G. M. T. 14^h 37^mObserved by J. N. TRIBBLE.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.6086 | ..... | ..... | ..... | 2 | 53.1311 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8748 | .8752 | .0104 | + 15.09 | 2 | 45.3033 | ..... | ..... | ..... |
| 2 | 72.4466 | ..... | ..... | ..... | 1 | 45.2588 | .2290 | .0097 | - 10.12 |
| 2 | 54.7631 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.5206 | .4520 | .0394 | + 54.20 |
| $\frac{1}{2}$ | 54.0116 | .9915 | .0217 | + [21.98] | 2 | 27.3153 | ..... | ..... | ..... |

Weighted mean..... + 7.26

 V_a - 19.98 V_d - .11

Curvature..... - .28

Radial velocity..... - 13.1

*Check measurement.

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 951 (a).1907. July 18.
G. M. T. 14^h 50^mObserved by J. N. TRIBLE.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0275 | ..... | ..... | ..... | $\frac{1}{2}$ | 53.9282 | 0274 | 0576 | + [66.50] |
| $\frac{1}{2}$ | 72.8907 | 8738 | 0090 | + 13.06 | 2 | 53.0075 | ..... | ..... | ..... |
| 2 | 72.4593 | ..... | ..... | ..... | 2 | 45.1272 | ..... | ..... | ..... |
| 2 | 54.6480 | ..... | ..... | ..... | $\frac{1}{2}$ | 45.0922 | 2386 | 0001 | - 18.0 |

Weighted mean..... - 2.53
 V_a - 20.16
 V_d - 14
 Curvature..... - .28

Radial velocity..... - 18.0

 α CORONÆ BOREALIS, 951 (b).1907. July 18.
G. M. T. 15^hObserved by J. N. TRIBLE.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0220 | ..... | ..... | ..... | 1 | 53.8272 | 0264 | 0264 | - [30.38] |
| $\frac{1}{2}$ | 72.8730 | 8616 | 0032 | - 4.64 | 2 | 52.9927 | ..... | ..... | ..... |
| 2 | 72.4539 | ..... | ..... | ..... | 2 | 45.1147 | ..... | ..... | ..... |
| 2 | 54.6277 | ..... | ..... | ..... | $\frac{1}{2}$ | 45.0894 | 2395 | 0008 | + 8.35 |

Weighted mean..... - 0.31
 V_a - 20.16
 V_d - 14
 Curvature..... - .28

Radial velocity..... - 20.9

 α CORONÆ BOREALIS, 956 (a).1907. July 20.
G. M. T. 16^h 07^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|-------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9731 | ..... | ..... | ..... | 2 | 45.3021 | 2932 | 0445 | + 46.59 |
| 1 | 72.8743 | 8653 | 0448 | + 65.09 | 1 | 27.5473 | 5493 | 0621 | + 54.03 |
| $1\frac{1}{2}$ | 72.4128 | ..... | ..... | ..... | 3 | 27.3199 | ..... | ..... | ..... |
| 2 | 45.2925 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Weighted mean..... + 53.08
 V_a - 20.37
 V_d - 22
 Curvature..... - 28

Radial velocity..... + 32.2

9-10 EDWARD VII., A. 1910

α CORONÆ BOREALIS, 963 (α).

1907, July 23.
G. M. T. 14^h 32^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| $\frac{1}{2}$ | 73.4670 | ..... | ..... | ..... | $\frac{1}{2}$ | 54.0566 | .0256 | .0558 | [+ 64.22] |
| 1 | 72.8900 | 8860 | .0212 | + 30.76 | 2 | 50.0472 | ..... | ..... | ..... |
| 2 | 73.6944 | ..... | ..... | ..... |  |  |  |  |  |

V_s + 30.76
 V_d - 20.59
 V_d - .14
 Curvature - .28

Radial velocity..... + 9.8

α CORONÆ BOREALIS, 973 (α).

1907, Aug. 1.
G. M. T. 14^h 06^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Lines. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Lines. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|-----------------------------|--------------------------------------|-----------|-----|-------------------------|-----------------------------|--------------------------------------|-----------|
| 2 | 72.9868 | ..... | ..... | ..... | 2 | 45.2780 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8440 | .8210 | .0023 | + 3.34 | 1 | 45.2568 | .2624 | .0137 | + 14.34 |
| 2 | 72.4220 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean... + 10.67
 V_s - 20.98
 V_d - .14
 Curvature - .28

Radial velocity..... - 10.7

α CORONÆ BOREALIS, 973 (α)*.

1907, Aug. 1.
G. M. T. 14^h 06^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0688 | ..... | ..... | ..... | $\frac{1}{2}$ | 53.9750 | .9619 | .0079 | - 9.09 |
| $\frac{1}{2}$ | 72.8800 | .8807 | .0159 | + 23.07 | 2 | 53.1240 | ..... | ..... | ..... |
| 2 | 72.4485 | ..... | ..... | ..... | 2 | 45.2885 | ..... | ..... | ..... |
| 2 | 54.7562 | ..... | ..... | ..... | $\frac{1}{2}$ | 45.2552 | .2402 | .0015 | + 1.57 |

Weighted mean..... + 5.85
 V_s 20.98
 V_d - .14
 Curvature..... - .28

Radial velocity..... - 15.5

* Check measurement.

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 973 (b).1907. Aug. 1.
G. M. T. 14^h 20^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0342 | ..... | ..... | ..... | 1 | 45.2752 | .2335 | .0052 | - 5.45 |
| 2 | 45.3153 | ..... | ..... | ..... |  |  |  |  |  |

V_s - 5.43
 V_a - 20.98
 V_d - .14
 Curvature..... - .28

Radial velocity..... - 26.8

 α CORONÆ BOREALIS, 978.1907. Aug. 3.
G. M. T. 13^h 02^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9938 | ..... | ..... | ..... | 2 | 45.2426 | .2434 | .0054 | - 5.65 |
| 1 | 72.8526 | .8224 | .0037 | + 5.37 | 1 | 27.4524 | .4800 | .0165 | - 6.40 |
| 2 | 72.4294 | ..... | ..... | ..... | 2 | 27.2940 | ..... | ..... | ..... |
| 2 | 45.2828 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... - 3.08
 V_a - 20.98
 V_d - .08
 Curvature..... - .28

Radial velocity..... - 24.4

 α CORONÆ BOREALIS, 986.1907. Aug. 6.
G. M. T. 16^h 38^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72.9297 | ..... | ..... | ..... | 2 | 54.6972 | ..... | ..... | ..... |
| 1 | 72.8025 | .8363 | .0176 | + 25.57 | 1½ | 53.0647 | ..... | ..... | ..... |
| 1½ | 72.3657 | ..... | ..... | ..... | 2 | 45.2377 | ..... | ..... | ..... |
| 1 | 53.9672 | .0000 | .0434 | + [50.08] | 1 | 45.2437 | .2877 | .0390 | + 34.00 |

Weighted mean..... + 29.78
 V_a - 20.96
 V_d - .27
 Curvature..... - .28

Radial velocity..... + 8.3

9-10 EDWARD VII., A. 1910

α CORONÆ BOREALIS, 986.*

1907. Aug. 6.
G. M. T. 16^h 38^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|------------|
| 2 | 72° 9624 | ..... | ..... | ..... | 1 | 54° 0154 | 54° 0019 | °0553 | + [63° 93] |
| 1 | 72° 8494 | 72° 8504 | °0317 | + 46° 06 | 2 | 45° 2934 | ..... | ..... | ..... |
| 2 | 72° 3988 | ..... | ..... | ..... | 1½ | 45° 2948 | 45° 2850 | °0363 | + 38° 00 |
| 1 | 54° 0288 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... + 41° 22

V_a..... - 20° 96V_d..... - 27

Curvature..... - 28

Radial velocity..... + 19° 7

* Check measurement.

α CORONÆ BOREALIS, 1006.

1907. Aug. 12.
G. M. T. 16^h 36^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|------------|
| 2 | 72° 8216 | ..... | ..... | ..... | 1 | 53° 9092 | 53° 9903 | °0205 | + [23° 66] |
| 1½ | 72° 6801 | 72° 8664 | °0016 | + 2° 32 | 2 | 45° 2372 | ..... | ..... | ..... |
| 2 | 72° 2641 | ..... | ..... | ..... | 1½ | 45° 2140 | 45° 2504 | °0117 | + 12° 25 |
| 2 | 53° 9477 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean..... + 7° 28

V_a..... - 20° 76V_d..... - 28

Curvature..... - 28

Radial velocity..... - 14° 0

α CORONÆ BOREALIS, 1014.

1907. Aug. 15.
G. M. T. 15^h 09^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|------------|
| 2 | 72° 9915 | ..... | ..... | ..... | 2 | 53° 9737 | 53° 9813 | °0115 | + [13° 24] |
| 1½ | 72° 8396 | 72° 8573 | 0075 | - 10° 88 | 2 | 53° 1065 | ..... | ..... | ..... |
| 2 | 72° 4290 | ..... | ..... | ..... | 2 | 45° 2707 | ..... | ..... | ..... |
| 2 | 54° 7321 | ..... | ..... | ..... | 1½ | 45° 2197 | 45° 2226 | °0161 | + 16° 81 |

Weighted mean..... + 13° 84

V_a..... - 20° 58V_d..... - 24

Curvature..... - 28

Radial velocity..... - 7° 3

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1917.1907. Aug. 22.
G. M. T. 15^hObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 $\frac{1}{2}$ | 45.7844 | ..... | ..... | ..... | $\frac{1}{2}$ | 45.7576 | 45.2448 | .0061 | + 6.37 |

V_s + 6.37
 V_a -19.90
 V_d - .20
 Curvature..... - .28

Radial velocity -14.0

 α CORONÆ BOREALIS, 1922.1907. Aug. 23.
G. M. T. 14^h 46^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 56.6754 | ..... | ..... | ..... | 2 | 45.2730 | ..... | ..... | ..... |
| 1 | 54.0042 | 53.9960 | .0262 | + [30.16] | $\frac{1}{2}$ | 45.2628 | 45.2634 | .0247 | +25.78 |
| 2 | 53.1214 | ..... | ..... | ..... |  |  |  |  |  |

V_s +25.78
 V_a -19.80
 V_d 24
 Curvature..... - .28

Radial velocity..... + 5.5

 α CORONÆ BOREALIS, 1926.1907. Aug. 27.
G. M. T. 12^h 06^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0220 | ..... | ..... | ..... | 2 | 45.2880 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.9344 | 72.9232 | .0084 | + 84.74 | $\frac{1}{8}$ | 27.4870 | 27.4500 | .0281 | + 32.50 |
| 2 | 72.4630 | ..... | ..... | ..... | 2 | 27.2840 | ..... | ..... | ..... |
| 2 | 54.0444 | ..... | ..... | ..... | $\frac{1}{8}$ | 45.2840 | 45.2696 | .0310 | + 32.36 |
| $\frac{1}{8}$ | 54.0000 | 53.9844 | .0146 | + [16.80] | | | | | |

Weighted mean +49.87
 V_a -19.35
 V_d - .19
 Curvature..... - .28

Radial velocity..... +30.0

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1032.1907. Sept. 6.
G. M. T. 13^h 43^mObserved by J. N. TRIBBLE.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73·0155 | | | | 2 | 45·2322 | | | |
| 1 $\frac{1}{2}$ | 72·8710 | 72·8631 | ·0017 | - 2·46 | 1 | 45·1848 | 45·2273 | ·0114 | -13·05 |
| 2 | 72·4595 | .. | .. | .. | 1 $\frac{1}{2}$ | 27·3358 | 27·4204 | ·0078 | - 6·77 |
| 2 | 54·7134 | | | | 2 | 27·1818 | | | |
| 1 $\frac{1}{2}$ | 53·9360 | 53·9634 | ·0064 | - [7·36] | 1 $\frac{1}{2}$ | 11·7425 | 11·8493 | ·0021 | - 1·57 |
| 2 | 53·0852 | .. | .. | .. | 2 | 11·4098 | | | |

Weighted mean - 4·50
 V_a -17·34
 V_d - ·25
 Curvature - ·28

Radial velocity -22·4

 α CORONÆ BOREALIS, 1037.1907. Sept. 12.
G. M. T. 14^h 40^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72·9383 | | | | 1 | 45·1575 | 45·2878 | ·0491 | +51·20 |
| 1 $\frac{1}{2}$ | 72·8230 | 72·8950 | ·0302 | +43·82 | 1 $\frac{1}{2}$ | 27·3467 | 27·5090 | ·0964 | +83·52 |
| 2 | 72·3715 | | | | 2 | 27·0843 | | | |
| 2 | 45·1433 | | | | | | | | |

Weighted mean +52·93
 V_a -16·20
 V_d - ·28
 Curvature - ·28

Radial velocity +35·2

 α CORONÆ BOREALIS, 1047.1907. Sept. 18.
G. M. T. 12^h 50^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73·1431 | | | | 2 | 45·3762 | | | |
| 1 | 72·9930 | 72·8596 | ·0052 | - 7·55 | 1 | 45·3585 | 45·2560 | ·0173 | +18·06 |
| 1 $\frac{1}{2}$ | 72·5787 | | | | | | | | |

Weighted mean + 5·25
 V_a -14·94
 V_d - ·25
 Curvature - ·28

Radial velocity -10·2

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1048.1907. Sept. 18.
G. M. T. 13^h 16^mObserved by J. N. TRIBBLE.
Measured by W. E. HARPER and J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73·0030 | ..... | ..... | ..... | $\frac{1}{2}$ | 53·9418 | 53·9718 | ·0020 | + [2·30] |
| $\frac{1}{2}$ | 72·8640 | 72·8695 | 0047 | + 6·82 | 2 | 53·0866 | ..... | ..... | ..... |
| 2 | 72·4433 | ..... | ..... | ..... | 2 | 45·1702 | ..... | ..... | ..... |
| 2 | 57·8023 | ..... | ..... | ..... | 1 | 45·1457 | 45·2339 | ·0048 | - 5·00 |
| 1 | 57·7850 | 57·7895 | ·0373 | - (44·91) | $\frac{1}{2}$ | 27·3310 | 27·3870 | ·0256 | - 22·22 |
| 2 | 54·7113 | ..... | ..... | ..... | 2 | 27·1905 | ..... | ..... | ..... |

Weighted mean - 4·09
 V_a - 14·94
 V_d - ·28
 Curvature - ·28

Radial velocity - 19·6

 α CORONÆ BOREALIS, 1060.1907. Sept. 20.
G. M. T. 13^h 35^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73·0090 | ..... | ..... | ..... | 2 | 53·0627 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72·8367 | 72·8376 | ·0272 | - 39·46 | 2 | 45·2140 | ..... | ..... | ..... |
| 2 | 72·4435 | ..... | ..... | ..... | 1 | 45·1690 | 45·2286 | ·0101 | - 10·54 |
| 2 | 54·6952 | ..... | ..... | ..... | $\frac{1}{2}$ | 27·3412 | 27·4192 | ·0066 | + 5·73 |
| $\frac{1}{2}$ | 53·8872 | 53·9352 | ·0346 | - [39·82] | 2 | 27·1682 | ..... | ..... | ..... |

Weighted mean - 10·02
 V_a - 14·52
 V_d + ·02
 Curvature - ·28

Radial velocity - 24·8

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1083.1907. October 1.
G. M. T. 13^h 44^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 73.0679 | ..... | ..... | ..... | 2 | 45.3609 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.9652 | 72.9078 | .0430 | +62.39 | $\frac{1}{2}$ | 45.3694 | 45.2857 | .0470 | +49.07 |
| 2 | 72.5002 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.5686 | 27.4492 | .0366 | +31.77 |
| 2 | 54.8129 | ..... | ..... | ..... | 2 | 27.3661 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 54.0989 | 54.0261 | .0563 | +[64.80] | 1 | 12.0432 | 11.9027 | .0513 | +38.42 |
| 2 | 53.1867 | ..... | ..... | ..... | 2 | 11.6482 | ..... | ..... | ..... |

Weighted mean. +43.25
 V_a -12.21
 V_d 28
Curvature28
Radial velocity +30.5

 α CORONÆ BOREALIS, 1084.1907. Oct. 1.
G. M. T. 13^h 56^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72.9948 | ..... | ..... | ..... | 2 | 45.2968 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8698 | 72.8852 | .0204 | +29.60 | $\frac{1}{2}$ | 45.2912 | 45.2680 | .0263 | +30.59 |
| 2 | 72.4285 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean. +30.27
 V_a -12.21
 V_d 28
Curvature28
Radial velocity +17.5

 α CORONÆ BOREALIS, 1393.1908. March 9.
G. M. T. 22^h 08^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.8725 | ..... | ..... | ..... | $2\frac{1}{2}$ | 27.5088 | 27.4056 | .0070 | -6.08 |
| $1\frac{1}{2}$ | 54.0542 | 53.9269 | .0429 | -[49.38] | 3 | 27.3499 | ..... | ..... | ..... |
| 2 | 53.2361 | ..... | ..... | ..... | $1\frac{1}{2}$ | 11.9342 | 11.8522 | .0008 | +0.60 |
| 3 | 45.3847 | ..... | ..... | ..... | 3 | 11.5892 | ..... | ..... | ..... |
| 2 | 45.3252 | 45.2141 | .0246 | -25.68 | | | | | |

Weighted mean. -10.94
 V_a +16.98
 V_d 66
Curvature28
Radial velocity +5.7

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1393*.1908. March 9.
G. M. T. 22^h 03^m 00^sObserved by W. E. HARPER.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|----------|
| 2 | 54.7344 | | | | 1 | 27.3712 | 27.3992 | .0134 | -11.63 |
| 2 | 53.9241 | 53.9316 | .0382 | -(43.97) | 2 | 27.2184 | | | |
| 2 | 53.1045 | | | | 1 | 11.7835 | 11.8301 | .0213 | -15.95 |
| 2 | 45.2517 | | | | 2 | 11.4603 | | | |
| 2 | 45.1867 | 45.2087 | .0300 | 31.32 | | | | | |

Weighted mean..... -22.55
 V_a +16.98
 V_d - .05
Curvature..... - .28

Radial velocity..... - 5.9

Note.—(Mg. line omitted).

* Check measurement.

 α CORONÆ BOREALIS, 1393. *1908. March 9.
G. M. T. 22^h 03^m 00^sObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7502 | | | | 1 $\frac{1}{2}$ | 45.2112 | 45.2051 | .0336 | -35.08 |
| 1 | 53.9539 | 53.9413 | .0285 | -(32.80) | 1 | 27.3758 | 27.3827 | .0299 | -25.95 |
| 2 | 53.1290 | | | | 2 | 27.2307 | | | |
| 2 | 45.2797 | | | | | | | | |

Weighted mean..... -31.43
 V_a +16.98
 V_d - .05
Curvature..... - .28

Radial velocity..... - 14.8

* Check measurement.

9-10 EDWARD VII., A. 1910

α CORONÆ BOREALIS, 1492.

1908, March 16.
G. M. T. 21^h 02^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 54 7845 | ..... | ..... | ..... | 1 | 27 5345 | 27 3875 | 0251 | - 21 79 |
| 1 | 53 9802 | 53 9412 | 0286 | - [32 92] | 2 | 27 3906 | ..... | ..... | ..... |
| 1 | 53 1475 | ..... | ..... | ..... | 1½ | 11 9963 | 11 7940 | 0574 | - 43 00 |
| 1 | 45 3466 | ..... | ..... | ..... | 2 | 11 7098 | ..... | ..... | ..... |
| 1 | 45 2690 | 45 1960 | 0427 | - 44 58 | | | | | |

Weighted mean -37 39

 V_a +20 74 V_d 00

Curvature - 28

Radial velocity - 16 9

α CORONÆ BOREALIS, 1493.

1908, April 15.
G. M. T. 19^h 18^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 45 2842 | ..... | ..... | ..... | 2 | 15 5026 | ..... | ..... | ..... |
| 1 | 45 2361 | 45 2254 | 0133 | - 13 88 | ½ | 15 5417 | 15 4377 | 0356 | - 27 55 |
| 1 | 27 4702 | 27 4039 | 0087 | - 7 55 | 1½ | 11 9500 | 11 8426 | 0088 | - 6 59 |
| 2 | 27 3135 | ..... | ..... | ..... | 2 | 11 6149 | ..... | ..... | ..... |

Weighted mean -13 89

 V_a + 5 85 V_d - 04

Curvature - 28

Radial velocity - 8 4

α CORONÆ BOREALIS, 1493.*

1908, April 15.
G. M. T. 19^h 18^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 72 9717 | ..... | ..... | ..... | 2 | 45 2297 | 45 2191 | 0196 | - 20 46 |
| 1½ | 72 8300 | 72 8678 | 0030 | + 4 35 | 1½ | 27 4633 | 27 4012 | 0114 | - 9 89 |
| 2 | 72 4080 | ..... | ..... | ..... | 2 | 27 3090 | ..... | ..... | ..... |
| 2 | 45 2812 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean - 9 85

 V_a + 5 85 V_d - 04

Curvature - 28

Radial velocity - 4 3

*Check measurement.

9-10 EDWARD VII., A. 1910

a CORONÆ BOREALIS, 1572.

1908. June 3.
G. M. T. 16^h 52^mObserved by J. S. PLASKETT.
Measured by C. R. WESTLAND.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7690 | | | | 2 | 27.3380 | | | |
| 12 | 53.9965 | 53.9706 | .0068 | + [1.16] | 2 | 15.5674 | 15.4394 | .0339 | - 26.24 |
| 12 | 53.1417 | | | | 2 | 15.5266 | | | |
| 12 | 45.3179 | | | | 2 | 11.9767 | 11.8434 | .0080 | - 5.99 |
| 12 | 45.2866 | 45.2423 | .0036 | + 3.76 | 2 | 11.6410 | | | |
| 12 | 27.4982 | 27.4073 | .0053 | - 4.60 | | | | | |

Weighted mean - 3.98
 V_a - 11.02
 V_d - .08
Curvature - .28
Radial velocity - 15.4

a CORONÆ BOREALIS, 1572*.

1908. June 3.
G. M. T. 16^h 52^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 1 | 53.9962 | 53.9677 | .0021 | - [2.41] | 2 | 27.3409 | | | |
| 2 | 54.7700 | | | | 1 | 15.5560 | 15.4260 | .0473 | - 36.61 |
| 2 | 45.3195 | | | | 2 | 15.5286 | | | |
| 1 | 45.2856 | 45.2396 | .0009 | + 0.93 | 2 | 11.9830 | 11.8501 | .0013 | - 9.74 |
| 2 | 43.5855 | | | | 2 | 11.6401 | | | |
| 2 | 27.5096 | 27.4153 | .0027 | + 2.34 | | | | | |

Weighted mean - 8.41
 V_a - 11.02
 V_d - .08
Curvature - .28
Radial velocity - 19.8

* Check measurement.

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1581.1908. June 5.
G. M. T. 17^h 31^mObserved by } W. E. HARPER
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72 9780 | ..... | ..... | ..... | 1 | 27 3975 | 27 4026 | 0000 | - 8 63 |
| 1 | 72 8496 | 72 8638 | 0040 | + 5 80 | 2 | 27 2433 | ..... | ..... | ..... |
| 2 | 72 4202 | ..... | ..... | ..... | 1 | 11 8584 | 11 8491 | 0023 | - 1 72 |
| 2 | 45 2545 | ..... | ..... | ..... | 2 | 11 5145 | ..... | ..... | ..... |
| 2 | 45 2387 | 45 2578 | 0191 | +19 94 | | | | | |

Weighted mean + 7 06

 V_a -11 62 V_d - 14

Curvature..... - 28

Radial velocity..... - 5 0

 α CORONÆ BOREALIS, 1601.1908. June 12.
G. M. T. 16^h 56^mObserved by } W. E. HARPER
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72 9665 | ..... | ..... | ..... | 2 | 53 0720 | ..... | ..... | ..... |
| 1 | 72 8330 | 72 8678 | 0030 | + 4 35 | 2 | 45 2242 | 45 2568 | 0181 | +28 18 |
| 1 | 72 4060 | ..... | ..... | ..... | 2 | 45 2410 | ..... | ..... | ..... |
| 2 | 54 7068 | ..... | ..... | ..... | 1½ | 27 4228 | 27 4370 | 0244 | +21 27 |
| ½ | 53 9350 | 53 9725 | 0027 | + [3 11] | 2 | 27 2322 | ..... | ..... | ..... |

Weighted mean +20 58

 V_a -13 59 V_d - 12

Curvature - 28

Radial velocity + 6 6

9-10 EDWARD VII., A. 1910

α CORONÆ BOREALIS, 1608.

1908, June 17.
G. M. T. 13^h 53^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 72 9809 | | | | 2 | 45 2620 | | | |
| 1 | 72 8361 | 72 8662 | 0014 | + 2 03 | 2 | 45 2390 | 45 2596 | 0119 | + 12 42 |
| 2 | 72 4112 | | | | 1 | 27 4892 | 27 4739 | 0613 | + 53 21 |
| 2 | 54 7169 | | | | 2 | 27 2621 | | | |
| 1 | 53 9506 | 53 9716 | 0018 | + [2 07] | 1 | 11 9270 | 11 8964 | 0450 | + 33 70 |
| 2 | 53 6941 | | | | 2 | 11 5379 | | | |

Weighted mean..... +23 76

V_a..... -14 85V_d..... 07

Curvature..... - 28

Radial velocity..... + 8 6

α CORONÆ BOREALIS, 1623.

1908, June 22.
G. M. T. 16^h 27^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54 7556 | | | | 1 | 27 4580 | 27 4130 | 0004 | + 3 47 |
| 2 | 53 9719 | 53 9559 | 0139 | - [16 00] | 3 | 27 2899 | | | |
| 2 | 53 1320 | | | | 1 | 11 9219 | 11 8454 | 0060 | - 4 49 |
| 2 | 45 2819 | | | | 2 | 11 5853 | | | |
| 1 | 45 2571 | 45 2511 | 0124 | + 12 93 | | | | | |

Weighted mean..... 3 97

V_a..... -16 16V_d..... - 16

Curvature..... - 28

Radial velocity..... -12

SESSIONAL PAPER No. 25a

a CORONÆ BOREALIS, 1623.

1908, June 22,
G. M. T. 16^h 27^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0044 | | | | 2 | 45.3000 | | | |
| 1 | 72.8548 | 72.8598 | .0050 | - 7.25 | 1 | 45.2624 | 45.2364 | .0023 | - 2.40 |
| 2 | 72.4483 | | | | 1 | 27.4675 | 27.4195 | .0024 | - 2.08 |
| 2 | 54.7536 | | | | 3 | 27.2552 | | | |
| 2 | 53.9681 | 53.9531 | .0167 | [19.22] | 1 | 11.9274 | 11.8594 | .0080 | - 5.99 |
| 2 | 53.1381 | | | | 2 | 11.5790 | | | |

Weighted mean. - 1.44
 V_a -16.16
 V_d - .16
 Curvature - .28

*Check measurement.

Radial velocity -18.0

a CORONÆ BOREALIS, 1624.

1908, June 22,
G. M. T. 16^h 40^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|----------|
| 2 | 54.7898 | | | | 1 | 27.4840 | 27.4175 | .0049 | + 4.34 |
| 1 | 54.0178 | 53.9700 | .0002 | ±[0.00] | 2 | 27.3131 | | | |
| 2 | 53.1597 | | | | 1½ | 11.9423 | 11.8612 | .0098 | + 7.34 |
| 2 | 45.3251 | | | | 2 | 11.5883 | | | |
| 1½ | 45.2880 | 45.2305 | .0023 | - 2.40 | | | | | |

Weighted mean. + 4.02
 V_a -16.16
 V_d - .16
 Curvature - .28

Radial velocity -12.6

a CORONÆ BOREALIS, 1628.

1908, June 24,
G. M. T. 15^h 26^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7838 | | | | 1 | 27.4598 | 27.4158 | .0032 | + 2.7 |
| 1 | 53.9417 | 53.9000 | .0698 | - [80.33] | 2 | 27.2908 | | | |
| 2 | 53.1536 | | | | 1½ | 11.9065 | 11.8706 | .0191 | +14.30 |
| 2 | 45.3060 | | | | 2 | 11.5432 | | | |
| 1 | 45.2761 | 45.2436 | .0049 | + 5.12 | | | | | |

Weighted mean. + 8.38
 V_a -16.65
 V_d - .07
 Curvature - .28

Radial velocity - 8.6

9-10 EDWARD VII., A. 1910

α CORONÆ BOREALIS, 1629.

1908, June 24.
G. M. T. 15^h 49^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0846 | | | | 2 | 45.3268 | | | |
| 1 | 72.9449 | 72.8698 | .0050 | + 7.26 | 1 | 45.2795 | 45.2263 | .0124 | -12.95 |
| 1 | 72.5206 | | | | 1 | 27.4625 | 27.4000 | .0126 | -10.93 |
| 2 | 54.7909 | | | | 2 | 27.3093 | | | |
| 1½ | 54.0511 | 53.9939 | .0241 | + [27.74] | 1 | 11.9286 | 11.8711 | .0197 | +14.77 |
| 2 | 53.1682 | | | | 2 | 11.5643 | | | |

Weighted mean..... 0.00
 V_a -16.66
 V_d - .11
 Curvature..... - .28

Radial velocity..... -17.0

α CORONÆ BOREALIS, 1638.

1908, June 26.
G. M. T. 15^h 51^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0800 | | | | 1½ | 45.3098 | 45.2238 | .0149 | -15.56 |
| 1 | 72.9496 | 72.8476 | .0172 | -24.96 | 2 | 45.3565 | | | |
| 1 | 72.5498 | | | | 2 | 27.4673 | 27.3933 | .0193 | -16.80 |
| 2 | 54.8334 | | | | 3 | 27.3236 | | | |
| 1 | 54.0511 | 53.9601 | .0097 | - [11.31] | 2 | 11.9232 | 11.8627 | .0113 | + 8.46 |
| 2 | 53.2007 | | | | 3 | 11.5652 | | | |

Weighted mean..... -10.00
 V_a -14.50
 V_d11
 Curvature..... - .28

Radial velocity..... -24.9

α CORONÆ BOREALIS, 1639.

1908, June 26th.
G. M. T. 15^h 51^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0632 | | | | 2 | 53.1470 | | | |
| 1 | 72.9112 | 72.8562 | .0086 | -12.48 | 2 | 45.3037 | | | |
| 1 | 72.5014 | | | | 1½ | 45.2656 | 45.2376 | .0011 | - 1.15 |
| 1½ | 54.7831 | | | | 1½ | 27.4499 | 27.4169 | .0043 | + 3.73 |
| 1 | 54.0126 | 53.9776 | .0078 | + [8.98] | 2 | 27.2799 | | | |

Weighted mean..... - 2.40
 V_a -14.81
 V_d - .11
 Curvature..... - .28

Radial velocity..... -17.6

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1646,1908. June 27.
G. M. T. 16^h 20^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 $\frac{1}{2}$ | 73° 0138 | | | | 1 | 45° 2252 | 45 2282 | 0105 | - 10 95 |
| $\frac{1}{2}$ | 72° 8550 | 72° 8552 | 0096 | - 13° 92 | 2 | 45° 2694 | | | |
| 1 $\frac{1}{2}$ | 72° 4403 | | | | 1 $\frac{1}{2}$ | 27° 4472 | 27° 4290 | 0164 | + 14 23 |
| 2 | 54° 7419 | | | | 2 | 27° 2648 | | | |
| 1 | 53° 9706 | 53° 9751 | 0053 | + [6 17] | 3 | 11° 8531 | 11° 8231 | 0283 | 21 19 |
| 2 | 53° 0627 (?) | | | | 3 | 11° 5348 | | | |

| | |
|-----------------|---------|
| Weighted mean | - 7 79 |
| V_a | - 14 98 |
| V_d | - 11 |
| Curvature | - 28 |
| Radial velocity | - 23 2 |

 α CORONÆ BOREALIS, 1646*.1908. June 27.
G. M. T. 16^h 20^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----------------|-------------------------|--------------------------------|--------------------------------------|------------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73° 0388 | | | | 2 | 45° 2924 | | | |
| $\frac{1}{2}$ | 72° 8666 | 72° 8466 | 0182 | - 26° 41 | 1 $\frac{1}{2}$ | 45° 2510 | 45° 2325 | 0062 | - 6 41 |
| 1 $\frac{1}{2}$ | 72° 4615 | | | | 1 $\frac{1}{2}$ | 27° 4381 | 27° 4092 | 0034 | - 3 05 |
| 2 | 54° 7608 | | | | 3 | 27° 2754 | | | |
| $\frac{1}{2}$ | 54° 0203 | 54 0038 | 0340 | + [39° 13] | 1 | 11° 9032 | 11° 8575 | 0061 | + 5 29 |
| 2 | 53° 1283 | | | | 3 | 11° 5531 | | | |

| | |
|-----------------|---------|
| Weighted mean | - 4 91 |
| V_a | - 14 98 |
| V_d | - 11 |
| Curvature | - 28 |
| Radial velocity | - 20 3 |

* Check measurement.

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1646.*1908. June 27.
G. M. T. 16^h 20^mObserved by J. S. PLASKETT.
Measured by W. E. HARPER.

| Wt. | Mean of Settings | Corrected Star Settings | Displacement in Revolutions | Velocity. | Wt. | Mean of Settings | Corrected Star Settings | Displacement in Revolutions | Velocity. |
|---------------|------------------|-------------------------|-----------------------------|-----------|-----|------------------|-------------------------|-----------------------------|-----------|
| 1 | 72 9272 | | | | 2 | 45 1872 | | | |
| | 92 7747 | 72 8581 | 0067 | - 8 72 | 2 | 45 1430 | 45 2294 | 0093 | - 9 71 |
| | 73 3578 | | | | 1 | 27 3550 | 27 4286 | 0160 | -13 39 |
| | 54 6545 | | | | 2 | 27 1731 | | | |
| | 53 8697 | 53 9617 | 0081 | - [9 32] | 1 | 11 7667 | 11 8341 | 0173 | -12 96 |
| $\frac{1}{2}$ | 53 0153 | | | | 2 | 11 4398 | | | |
| Weighted mean | | | | | | | | | - 5 44 |
| V_a | | | | | | | | | -14 98 |
| V_d | | | | | | | | | - 11 |
| Curvature | | | | | | | | | 28 |

* Check measurement.

Radial velocity 20 8

 α CORONÆ BOREALIS, 1647.1908. June 27.
G. M. T. 16^h 40^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings | Corrected Star Settings | Displacement in Revolutions | Velocity. | Wt. | Mean of Settings | Corrected Star Settings | Displacement in Revolutions | Velocity. |
|---------------|------------------|-------------------------|-----------------------------|-----------|-----|------------------|-------------------------|-----------------------------|------------|
| 1 | 73 0577 | | | | 2 | 45 3388 | | | |
| $\frac{1}{3}$ | 72 9089 | 72 8589 | 0059 | - 8 56 | 1 | 45 3041 | 45 2387 | 0000 | \pm 0 00 |
| 1 | 72 5000 | | | | 1 | 27 4771 | 27 3891 | 0235 | - 20 40 |
| 2 | 54 7978 | | | | 2 | 27 3349 | | | |
| 1 | 54 0373 | 53 9793 | 0095 | - [10 93] | 1 | 11 9502 | 11 8522 | 0008 | - 0 60 |
| 2 | 53 1731 | | | | 2 | 11 6053 | | | |
| Weighted mean | | | | | | | | | - 6 59 |
| V_a | | | | | | | | | -14 03 |
| V_d | | | | | | | | | - 16 |
| Curvature | | | | | | | | | - 28 |

Radial velocity -21 1

 α CORONÆ BOREALIS, 1652.1908. July 1.
G. M. T. 15^h 15^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings | Corrected Star Settings | Displacement in Revolutions | Velocity. | Wt. | Mean of Settings | Corrected Star Settings | Displacement in Revolutions | Velocity. |
|---------------|------------------|-------------------------|-----------------------------|-----------|-----|------------------|-------------------------|-----------------------------|-----------|
| 1 | | | | | 1 | 45 0548 | 45 3038 | 0051 | +67 96 |
| $\frac{1}{2}$ | 72 6304 | 72 8917 | 0269 | +38 03 | 2 | 45 6254 | | | |
| 1 | 72 1836 | | | | 1 | 27 2465 | 27 4801 | 0675 | +58 59 |
| 2 | 54 4896 | | | | 2 | 27 0134 | | | |
| $\frac{1}{2}$ | 53 7812 | 53 0387 | 0689 | + [79 30] | 1 | 11 7141 | 11 9391 | 0877 | +64 69 |
| 2 | 52 8512 | | | | 2 | 11 2829 | | | |
| Weighted mean | | | | | | | | | -60 07 |
| V_a | | | | | | | | | -17 78 |
| V_d | | | | | | | | | - 07 |
| Curvature | | | | | | | | | 28 |

Radial velocity -41 9

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1656.1908. July 3.
G. M. T. 15^h 17^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| $\frac{1}{2}$ | 54.7645 | | | | $\frac{1}{2}$ | 27.4941 | 27.4896 | .0640 | +59.02 |
| $\frac{1}{2}$ | 54.0431 | 54.0196 | .0498 | + [57.32] | 2 | 27.2509 | | | |
| $\frac{1}{2}$ | 53.1362 | | | | $\frac{1}{2}$ | 11.8955 | 11.8895 | .0381 | +28.54 |
| $\frac{1}{2}$ | 45.2983 | | | | 2 | 11.5115 | | | |
| $\frac{1}{2}$ | 45.3190 | 45.2943 | .0656 | +58.05 | | | | | |

Weighted mean..... +48.53
 V_a -18.18
 V_d 11
 Curvature..... -28
 Radial velocity..... +30.0

 α CORONÆ BOREALIS, 1657.1908. July 3.
G. M. T. 15^h 30^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| $\frac{1}{2}$ | 54.6727 | | | | 1 | 45.2997 | 45.2817 | .0430 | +44.89 |
| $\frac{1}{2}$ | 53.9471 | 54.0011 | .0313 | +36.03 | 2 | 44.1900 | | | |
| $\frac{1}{2}$ | 53.0497 | | | | 1 | 27.3961 | 27.4586 | .0460 | +39.93 |
| $\frac{1}{2}$ | 45.2068 | | | | 2 | 27.1843 | | | |

Weighted mean..... +42.41
 V_a -18.18
 V_d 14
 Curvature..... -28
 Radial velocity..... +23.8

 α CORONÆ BOREALIS, 1665.1908. July 6.
G. M. T. 16^h 50^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 72.9692 | | | | $1\frac{1}{2}$ | 45.2173 | 45.2668 | .0281 | +29.34 |
| $\frac{1}{2}$ | 72.8398 | 72.8876 | .0228 | +33.08 | 2 | 45.2240 | | | |
| 1 | 72.3996 | | | | 1 | 27.4083 | 27.4290 | .0164 | +14.24 |
| 2 | 54.6898 | | | | 2 | 27.2265 | | | |
| $\frac{3}{4}$ | 53.9145 | 53.9715 | .0017 | + [1.96] | 1 | 11.8914 | 11.9154 | .0640 | +47.93 |
| $\frac{1}{2}$ | 53.0501 | | | | 2 | 11.4830 | | | |

Weighted mean..... +31.18
 V_a -18.72
 V_d 16
 Curvature..... -28
 Radial velocity..... +12.0

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1673.1908. July 8.
G. M. T. 14^h 59^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 72 9993 | | | | 2 | 45 27 46 | | | |
| $\frac{1}{2}$ | 72 8626 | 72 8721 | 0073 | +10 60 | 1 | 45 23 92 | 45 23 82 | 0005 | - 0 52 |
| 1 | 72 4371 | | | | $\frac{1}{2}$ | 27 45 64 | 27 42 27 | 0065 | + 5 64 |
| 2 | 54 73 14 | | | | 2 | 27 28 10 | | | |
| $\frac{1}{2}$ | 53 98 55 | 53 99 20 | 0022 | + [25 55] | $1\frac{1}{2}$ | 11 9 28 3 | 11 8 88 3 | 0360 | + 27 63 |
| 2 | 53 19 71 | | | | 1 | 11 5 47 2 | | | |

Weighted mean +14 01
 V_a -19 07
 V_d - 11
Curvature - 28

Radial velocity - 5 4

 α CORONÆ BOREALIS, 1674.1908. July 8.
G. M. T. 15^h 11^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54 72 42 | | | | 1 | 27 44 96 | 27 43 34 | 0208 | +18 05 |
| 1 | 53 95 36 | 53 97 11 | 0013 | + [1 50] | 2 | 27 26 31 | | | |
| 2 | 53 00 47 | | | | $1\frac{1}{2}$ | 11 89 26 | 11 86 51 | 0137 | +10 26 |
| 2 | 45 26 16 | | | | 2 | 11 53 51 | | | |
| 1 | 45 25 83 | 45 27 03 | 0316 | +32 99 | | | | | |

Weighted mean +18 98
 V_a -19 07
 V_d - 11
Curvature - 28

Radial velocity - 0 5

 α CORONÆ BOREALIS, 1683.1908. July 10.
G. M. T. 13^h 34^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73 03 09 | | | | 2 | 53 13 34 | | | |
| $\frac{1}{2}$ | 72 88 84 | 72 86 04 | 0046 | + 6 67 | 2 | 45 31 29 | | | |
| 1 | 72 46 03 | | | | $\frac{1}{2}$ | 45 26 67 | 45 22 74 | 0113 | -11 79 |
| 2 | 54 76 82 | | | | 1 | 27 48 32 | 27 41 12 | 0014 | - 1 22 |
| 1 | 54 04 51 | 54 02 11 | 0513 | + [59 04] | 2 | 27 31 88 | | | |

Weighted mean - 1 89
 V_a -19 38
 V_d 00
Curvature - 28

Radial velocity - 21 5

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1684.1908, July 10.
G. M. T. 13^h 57^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0327 | | | | 2 | 45.3009 | | | |
| $\frac{1}{2}$ | 72.8947 | 72.8737 | .0089 | +12.91 | 1 | 45.2694 | 45.2421 | .0034 | +3.54 |
| 1 | 72.4598 | | | | $1\frac{1}{2}$ | 27.4744 | 27.4221 | .0093 | +7.81 |
| 2 | 54.7653 | | | | 2 | 27.2995 | | | |
| $\frac{1}{2}$ | 53.9629 | 53.9399 | .0299 | -[34.41] | $\frac{1}{2}$ | 11.9048 | 11.8363 | .0151 | -11.30 |
| 2 | 53.1347 | | | | 2 | 11.5759 | | | |

Weighted mean..... - 4.59
 V_a -19.38
 V_d - .04
 Curvature..... - .28
 Radial velocity..... -15.1

 α CORONÆ BOREALIS, 1697.1908, July 13.
G. M. T. 15^h 36^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 72.9735 | | | | 2 | 45.2506 | | | |
| $\frac{1}{2}$ | 72.8268 | 72.8608 | .0040 | - 5.80 | $1\frac{1}{2}$ | 45.2284 | 45.2424 | .0037 | + 3.86 |
| 1 | 72.4159 | | | | $1\frac{1}{2}$ | 27.4218 | 27.3975 | .0151 | -13.11 |
| 2 | 54.7199 | | | | 2 | 27.2712 | | | |
| 1 | 53.9583 | 53.9828 | .0130 | + [14.96] | 1 | 11.8656 | 11.8236 | .0278 | -20.82 |
| 2 | 53.0846 | | | | 2 | 11.5495 | | | |

Weighted mean..... - 8.35
 V_a -19.79
 V_d - .19
 Curvature..... - .28
 Radial velocity..... -28.6

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1698.1908. July 13.
G. M. T. 15^h 42^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0061 | | | | 2 | 45.2766 | | | |
| $\frac{1}{2}$ | 72.8661 | 72.8691 | .0043 | + 6.24 | $1\frac{1}{2}$ | 45.2388 | 45.2358 | .0029 | - 3.03 |
| 1 | 72.4437 | | | | $1\frac{1}{2}$ | 27.4391 | 27.4144 | .0018 | + 1.56 |
| 2 | 54.7384 | | | | 2 | 27.2716 | | | |
| 1 | 53.9504 | 53.9544 | .0154 | -(17.72) | 1 | 11.8994 | 11.8619 | .0105 | + 7.86 |
| 2 | 53.1069 | | | | 2 | 11.5450 | | | |

Weighted mean..... + 1.84
 V_a -19.79
 V_d16
 Curvature..... - .28
 Radial velocity..... -18.4

 α CORONÆ BOREALIS, 1711.1908. July 13.
G. M. T. 16^h 24^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0341 | | | | $1\frac{1}{2}$ | 45.2779 | 45.2420 | .0033 | + 3.44 |
| $\frac{1}{2}$ | 72.8891 | 72.8647 | .0001 | - .15 | 1 | 27.4705 | 27.4115 | .0011 | - .95 |
| 2 | 54.7729 | | | | 2 | 27.3061 | | | |
| $1\frac{1}{2}$ | 54.0318 | 53.9990 | .0292 | +[33.61] | 1 | 11.9256 | 11.8468 | .0046 | .34 |
| 2 | 53.1470 | | | | 2 | 11.5865 | | | |
| 2 | 45.3094 | | | | | | | | |

Weighted mean..... + 3.79
 V_a -20.03
 V_d22
 Curvature..... - .28
 Radial velocity..... -16.7

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1721.1908. July 24.
G. M. T. 13^h 05^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73.0620 | ..... | ..... | ..... | 2 | 45.3273 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.9251 | 72.9711 | .0063 | + 9.14 | 1 | 45.3040 | 45.2503 | .0537 | +12.10 |
| 1 | 72.5018 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.5037 | 27.4317 | .0720 | +15.57 |
| 2 | 54.7950 | ..... | ..... | ..... | 2 | 27.3187 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 54.0282 | 53.9742 | .0540 | + [5.06] | 1 | 11.9502 | 11.8812 | .0690 | +20.97 |
| 2 | 53.1587 | ..... | ..... | ..... | 2 | 11.5759 | ..... | ..... | ..... |

Weighted mean..... +15.25
 V_a 20.68
 V_d04
 Curvature..... .28
 Radial velocity..... 5.7

 α CORONÆ BOREALIS, 1722.1908. July 24.
G. M. T. 13^h 21^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73.0441 | ..... | ..... | ..... | 2 | 45.3021 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.9200 | 72.8872 | .0328 | +32.50 | $\frac{1}{2}$ | 45.3022 | 45.2738 | .0284 | +36.64 |
| 1 | 72.4735 | ..... | ..... | ..... | 1 | 27.4681 | 27.4298 | .0383 | +14.95 |
| 2 | 54.7704 | ..... | ..... | ..... | 2 | 27.2830 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 54.0159 | 53.9881 | .0278 | + [21.06] | 1 | 11.9141 | 11.8766 | .0375 | +18.87 |
| 2 | 53.1390 | ..... | ..... | ..... | 2 | 11.5446 | ..... | ..... | ..... |

Weighted mean..... +26.25
 V_a 20.68
 V_d04
 Curvature..... .28
 Radial velocity..... 5.25

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1739.1908. July 29.
G. M. T. 15^h 34^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73 0080 | | | | 2 | 45 2276 | | | |
| $\frac{1}{2}$ | 72 8406 | 72 8439 | 0209 | -30 33 | $\frac{1}{2}$ | 45 1618 | 45 2078 | 0309 | -32 26 |
| 2 | 72 4370 | | | | 2 | 27 3167 | 27 3697 | 0519 | -45 14 |
| 2 | 54 7106 | | | | 2 | 27 1926 | | | |
| 1 | 53 9688 | 54 0038 | 0340 | -[30 13] | $\frac{1}{2}$ | 11 7853 | 11 8623 | 0109 | + 8 16 |
| 2 | 53 0733 | | | | 2 | 11 4290 | | | |

Weighted mean..... -29 78
 V_a -20 68
 V_d - 24
 Curvature..... - 28

Radial velocity..... -50 0

 α CORONÆ BOREALIS, 1739.*1908. July 29.
G. M. T. 15^h 34^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73 0854 | | | | 2 | 45 3015 | | | |
| $\frac{1}{2}$ | 72 9133 | 72 8398 | 0250 | -36 27 | 1 | 45 2452 | 45 2173 | 0214 | -22 34 |
| 2 | 72 5142 | | | | $\frac{1}{2}$ | 27 3747 | 27 3581 | 0545 | -36 29 |
| 2 | 54 7789 | | | | 2 | 27 2632 | | | |
| $\frac{1}{2}$ | 54 0256 | 53 9903 | 0265 | + [25 59] | 1 | 11 8647 | 11 8697 | 0183 | +13 70 |
| 2 | 53 1456 | | | | 2 | 11 5622 | | | |

Weighted mean..... -18 01
 V_a -20 91
 V_d - 22
 Curvature..... - 28

Radial velocity..... -39 4

*Check measurement.

SESSIONAL PAPER No. 25a

a CORONÆ BOREALIS, 1748.

1908. July 31.
G. M. T. 13^h 38^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73·0081 | | | | 2 | 53·1907 | | | |
| $\frac{1}{2}$ | 72·8616 | 72·8641 | ·0007 | -10·15 | 2 | 45·2606 | | | |
| 1 | 72·4501 | | | | 1 | 45·1969 | 45·2039 | ·0348 | -36·33 |
| 2 | 54·7326 | | | | $\frac{1}{2}$ | 27·3938 | 27·3994 | ·0132 | -11·45 |
| 1 | 53·9342 | 53·9445 | ·0250 | -[28·77] | 2 | 27·2521 | | | |

Weighted mean -19·53
 V_a -20·98
 V_d -14
Curvature -28
Radial velocity -40·9

a CORONÆ BOREALIS, 1749.

1908. July 31.
G. M. T. 13^h 38^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73·0321 | | | | 2 | 45·2724 | | | |
| $\frac{1}{2}$ | 72·8767 | 72·8559 | ·0089 | -11·91 | $\frac{1}{2}$ | 45·2269 | 45·2281 | ·0106 | -11·07 |
| 1 | 72·4611 | | | | 1 | 27·4144 | 27·4088 | ·0038 | -3·30 |
| 2 | 54·7470 | | | | 2 | 27·2523 | | | |
| 1 | 53·9854 | 53·9816 | ·0118 | + [13·58] | 1 | 11·8314 | 11·8384 | ·0160 | -11·98 |
| 2 | 53·1145 | | | | 2 | 11·4999 | | | |

Weighted mean -9·46
 V_a -20·98
 V_d -14
Curvature -28
Radial velocity -30·9

9-10 EDWARD VII. A. 1910

CORONÆ BOREALIS, 1761.

1908, Aug. 5.
G. M. T. 19^h 15^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|------------|----------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73.0055 | | | | 2 | 45.2722 | | | |
| $\frac{1}{2}$ | 72.9250 | 72.9281 | .0633 | +91.85 | $1\frac{1}{2}$ | 45.2899 | 45.2913 | .0526 | +54.91 |
| 1 | 72.4451 | | | | $\frac{1}{2}$ | 27.4955 | 27.4728 | .0602 | +52.25 |
| 2 | 54.7359 | | | | 2 | 27.2595 | | | |
| 1 | 54.0637 | 54.0699 | 1002 | + [115.33] | 1 | 11.9402 | 11.9365 | .0851 | +63.74 |
| 2 | 53.1055 | | | | 2 | 11.5107 | | | |

Weighted mean +58.42

 V_a -20.96 V_d -23

Curvature -28

Radial velocity +37.0

CORONÆ BOREALIS, 1773.

1908, Aug. 7.
G. M. T. 14^h 25^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|----------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7903 | | | | $\frac{1}{2}$ | 27.5854 | 27.5687 | .0961 | +83.41 |
| 1 | 54.0770 | 54.0281 | .0583 | + [67.10] | 2 | 27.3236 | | | |
| 2 | 53.1613 | | | | $\frac{1}{2}$ | 12.0157 | 11.9397 | .0883 | +66.14 |
| 2 | 45.3261 | | | | 2 | 11.5833 | | | |
| $1\frac{1}{2}$ | 45.3538 | 45.3013 | .0626 | +65.35 | | | | | |

Weighted mean -69.12

 V_a -20.91 V_d -19

Curvature -28

Radial velocity +47.7

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1775.1908. Aug. 7.
G. M. T. 14^h 40^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0279 | | | | 2 | 45.3045 | | | |
| $\frac{1}{2}$ | 72.9227 | 72.9056 | .0408 | +58.20 | 1 $\frac{1}{2}$ | 45.3313 | 45.3064 | .0617 | +64.41 |
| 1 | 72.4568 | | | | 1 | 27.5296 | 27.4692 | .0566 | +49.13 |
| 2 | 54.7633 | | | | 2 | 27.3107 | | | |
| 1 | 54.0103 | 53.9888 | .0190 | + [21.87] | 1 | 12.9051 | 11.9305 | .0791 | +59.25 |
| 2 | 53.1363 | | | | 2 | 11.5821 | | | |

Weighted mean..... +58.54

 V_a 20.91 V_d 19

Curvature..... .28

Radial velocity..... +37.5

 α CORONÆ BOREALIS, 1798.1908. Aug. 20.
G. M. T. 13^h 05^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0365 | | | | 2 | 53.1332 | | | |
| $\frac{1}{2}$ | 72.8789 | 72.8528 | .0120 | -17.41 | 2 | 45.2876 | | | |
| 1 | 72.4693 | | | | 1 | 45.2516 | 45.2376 | .0011 | - 1.15 |
| 2 | 54.7634 | | | | $\frac{1}{2}$ | 27.4337 | 27.4011 | .0115 | - 9.98 |
| 1 | 54.0034 | 53.9821 | .0123 | + [14.16] | 2 | 27.2794 | | | |

Weighted mean..... - 7.42

 V_a -30.11 V_d - 16

Curvature..... .28

Radial velocity..... - 28.0

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1798*1908. Aug. 20.
G. M. T. 13^h 05^mObserved by T. H. PARKER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73·0392 | | | | 2 | 45·3184 | | | |
| $\frac{1}{2}$ | 72·9039 | 72·8549 | ·0099 | -14·36 | 1 | 45·2919 | 45·2471 | ·0084 | +8·76 |
| 2 | 72·4926 | | | | 1 | 27·4682 | 27·4132 | ·0006 | +0·52 |
| 2 | 54·7890 | | | | 2 | 27·3016 | | | |
| $\frac{1}{2}$ | 54·0289 | 53·9824 | ·0126 | + [14·50] | 1 | 11·9196 | 11·8679 | ·0165 | +12·36 |
| 2 | 53·1569 | | | | 2 | 11·5385 | | | |

Weighted mean - 4·13

 V_a - 20·11 V_d - ·16

Curvature - ·28

Radial velocity - 16·4

* Check measurement.

 α CORONÆ BOREALIS, 1809.1908. Aug. 21.
G. M. T. 15^h 01^mObserved by J. B. CANNON.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73·0208 | | | | 2 | 45·2855 | | | |
| $\frac{1}{2}$ | 72·8951 | 72·8835 | ·0187 | -27·13 | 1 | 45·2607 | 45·2488 | ·0101 | +10·54 |
| 1 | 72·4582 | | | | $\frac{1}{2}$ | 27·4744 | 27·4424 | ·0298 | +25·87 |
| 2 | 54·7565 | | | | 2 | 27·2787 | | | |
| $\frac{1}{2}$ | 54·0087 | 53·9964 | ·0266 | + [30·62] | 1 | 11·9107 | 11·8762 | ·0248 | +18·58 |
| 2 | 53·1219 | | | | 2 | 11·5418 | | | |

Weighted mean - 18·54

 V_a - 20·00 V_d - ·25

Curvature - ·28

Radial velocity - 2·00

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1816.1908, Aug. 24.
G. M. T. 13^h 12^mObserved by W. E. HARPER
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.7497 | ..... | ..... | ..... | 1 | 45.3087 | 45.2922 | .0535 | +55.85 |
| $\frac{1}{2}$ | 54.0267 | 54.0182 | .0484 | -[55.71] | $\frac{1}{2}$ | 27.5132 | 27.4672 | .0546 | +47.38 |
| 2 | 53.1212 | ..... | ..... | ..... | 2 | 27.2950 | ..... | ..... | ..... |
| 2 | 45.2902 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean +53.03

 V_a -19.63 V_d - .20

Curvature - .28

Radial velocity + 32.9

 α CORONÆ BOREALIS, 1817.1908, Aug. 24.
G. M. T. 13^h 27^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 73.0283 | ..... | ..... | ..... | 2 | 45.2794 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.9461 | 72.9283 | .0635 | +92.13 | 1 | 45.2977 | 45.2920 | .0533 | +55.64 |
| 1 | 72.4579 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.5221 | 27.5085 | .0659 | +83.24 |
| 2 | 54.7488 | ..... | ..... | ..... | 2 | 27.2603 | ..... | ..... | ..... |
| 1 | 54.0279 | 54.0227 | .0529 | + [62.66] | $\frac{1}{2}$ | 11.9477 | 11.9257 | .0743 | +55.65 |
| 2 | 53.1145 | ..... | ..... | ..... | 2 | 11.5295 | ..... | ..... | ..... |

Weighted mean +68.45

 V_a -19.63 V_d - .20

Curvature - .28

Radial velocity + 48.3

 α CORONÆ BOREALIS, 1827.1908, Aug. 25.
G. M. T. 13^hObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 54.6765 | ..... | ..... | ..... | 1 | 45.2167 | 45.2857 | .0470 | +49.06 |
| 1 | 53.9543 | 54.0213 | .0515 | + [59.28] | $\frac{1}{2}$ | 27.4307 | 27.4547 | .0421 | +36.54 |
| 2 | 53.0434 | ..... | ..... | ..... | 2 | 27.2326 | ..... | ..... | ..... |
| 2 | 45.2046 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean +46.56

 V_a -19.51 V_d - .17

Curvature - .28

Radial velocity + 26.6

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1836.1908. Aug. 27.
G. M. T. 14^h 34^mObserved by J. B. CANNON
Measured by J. B. CANNON

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0226 | | | | 2 | 45.2911 | | | |
| $\frac{1}{2}$ | 72.8809 | 72.8770 | .0122 | 17.70 | 1 | 45.2916 | 45.2741 | .0354 | -36.95 |
| 1 | 72.4579 | | | | $\frac{1}{2}$ | 27.4906 | 27.4623 | .0497 | -43.13 |
| 2 | 54.7549 | | | | 2 | 27.2740 | | | |
| 1 | 53.9889 | 53.9763 | .0065 | -[7.48] | $\frac{1}{2}$ | 11.9036 | 11.8701 | .0187 | -14.00 |
| 2 | 53.1241 | | | | 2 | 11.5409 | | | |

Weighted mean..... 29.74

 V_d 19.21 V_d 28

Curvature..... 28

Radial velocity..... 10.0

 α CORONÆ BOREALIS, 1841.1908. Aug. 28.
G. M. T. 13^hObserved by J. B. CANNON
Measured by J. B. CANNON

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0259 | | | | $\frac{1}{2}$ | 27.5064 | 27.4684 | .0558 | -48.43 |
| $\frac{1}{2}$ | 72.8870 | 72.8701 | .0053 | + 7.69 | 2 | 27.2849 | | | |
| 1 | 72.4641 | | | | 1 | 11.9382 | 11.8832 | .0318 | 23.82 |
| 2 | 45.2921 | | | | 2 | 11.5626 | | | |
| 1 | 45.2848 | 45.2663 | .0276 | -28.81 | | | | | |

Weighted mean..... -24.94

 V_d 19.03 V_d 19

Curvature..... 28

Radial velocity..... + 5.4

SESSIONAL PAPER No. 25a

α CORONÆ BOREALIS, 1842.

1908, Aug. 28,
G. M. T. 13^h 14^mObserved by J. B. CANNON.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0092 | | | | 2 | 45.2878 | | | |
| $\frac{1}{2}$ | 72.8733 | 72.8738 | .0090 | +13.06 | 1 | 45.2838 | 45.2686 | .0309 | +32.26 |
| 1 | 72.4448 | | | | $\frac{1}{2}$ | 27.4765 | 27.4412 | .0286 | +24.82 |
| 2 | 54.7462 | | | | 2 | 27.2762 | | | |
| $\frac{1}{2}$ | 54.0117 | 54.0051 | .0353 | +39.63 | $\frac{1}{2}$ | 11.9601 | 11.9223 | .0709 | +55.10 |
| 2 | 53.1214 | | | | 2 | 11.5452 | | | |

Weighted mean 30.60

 V_a -19.63 V_d 20

Curvature28

Radial velocity 11.1

α CORONÆ BOREALIS, 1852.

1908, Aug. 31,
G. M. T. 13^h 17^mObserved by W. F. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0311 | | | | 1 | 27.4462 | 27.4423 | .0297 | +25.78 |
| $\frac{1}{2}$ | 72.8743 | 72.8536 | .0112 | -12.89 | 2 | 27.2515 | | | |
| 1 | 72.4637 | | | | $\frac{1}{2}$ | 11.8686 | 11.8702 | .0188 | +14.08 |
| 2 | 45.2785 | | | | 2 | 11.5056 | | | |
| $\frac{1}{2}$ | 45.2366 | 45.2317 | .0070 | -7.31 | | | | | |

Weighted mean +3.66

 V_a -18.53 V_d 22

Curvature28

Radial velocity 15.4

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1852*.1908, Aug. 31.
G. M. T. 13^h 17^mObserved by W. E. HARPER.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73·0047 | ..... | ..... | ..... | $\frac{1}{2}$ | 27·4278 | 27·4397 | ·0271 | +23·52 |
| $\frac{1}{2}$ | 72·8550 | 72·8598 | ·0050 | - 7·25 | 2 | 27·2347 | ..... | ..... | ..... |
| 1 | 72·4409 | ..... | ..... | ..... | $\frac{1}{2}$ | 11·8520 | 11·8750 | ·0236 | +17·68 |
| 2 | 45·2570 | ..... | ..... | ..... | 2 | 11·4840 | ..... | ..... | ..... |
| 1 | 45·2188 | 45·2354 | ·0033 | - 3·45 | | | | | |

Weighted mean + 4·05

 V_a - 18·53 V_d - 22

Curvature..... - 28

Radial velocity..... - 15·0

* Check Measurement

 α CORONÆ BOREALIS, 1861.1908, Sept. 3.
G. M. T. 12^h 50^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73·0328 | ..... | ..... | ..... | $\frac{1}{2}$ | 27·4429 | 27·4029 | ·0097 | - 8·42 |
| $\frac{1}{2}$ | 72·8769 | 72·8535 | ·0113 | - 16·40 | 2 | 27·2866 | ..... | ..... | ..... |
| 1 | 72·4697 | ..... | ..... | ..... | 1 | 11·8911 | 11·8395 | ·0119 | - 8·91 |
| 2 | 45·2913 | ..... | ..... | ..... | 2 | 11·5592 | ..... | ..... | ..... |
| 1 | 45·2442 | 45·2265 | ·0122 | - 12·74 | | | | | |

Weighted mean - 11·35

 V_a - 18·03 V_d - 21

Curvature..... - 28

Radial velocity..... - 29·9

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1865.1908, Sept. 4.
G. M. T. 13^h 27^mObserved by T. H. PARKER.
Measured by J. R. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 73.0201 | ..... | ..... | ..... | 2 | 45.2962 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8801 | 72.8693 | .0045 | + 6.53 | 1 | 45.2687 | 45.2461 | .0074 | + 7.73 |
| 1 | 72.4571 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.4456 | 27.3976 | .0150 | - 10.02 |
| 2 | 54.7639 | ..... | ..... | ..... | 2 | 27.2949 | ..... | ..... | ..... |
| 1 | 53.9634 | 53.9411 | .0287 | - [33.03] | $\frac{1}{2}$ | 11.9038 | 11.8461 | .0653 | - 3.97 |
| 2 | 53.1346 | ..... | ..... | ..... | 2 | 11.5651 | ..... | ..... | ..... |

Weighted mean + 3.75

 V_a - 17.87 V_d - .27

Curvature - .28

Radial velocity - 14.7

 α CORONÆ BOREALIS, 1882.1908, Sept. 14.
G. M. T. 12^h 51^mObserved by J. S. PLASKETT.
Measured by J. R. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 75.0319 | ..... | ..... | ..... | 2 | 45.3247 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.9093 | 72.8867 | .0219 | + 31.78 | 1 | 45.3219 | 45.2708 | .0321 | + 33.51 |
| 1 | 72.4692 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.5253 | 27.4463 | .0337 | + 29.25 |
| 2 | 54.7787 | ..... | ..... | ..... | 2 | 27.3257 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 54.0006 | 53.9646 | .0052 | - [5.99] | $\frac{1}{2}$ | 12.0035 | 11.8975 | .0451 | + 33.78 |
| 2 | 53.1472 | ..... | ..... | ..... | 2 | 11.6135 | ..... | ..... | ..... |

Weighted mean + 32.77

 V_a - 15.95 V_d - .23

Curvature - .28

Radial velocity + 16.3

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1883.1908, Sept. 14.
G. M. T. 13^h 07^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7551 | ..... | ..... | ..... | 2 | 27.2799 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 54.0166 | 54.0060 | 0362 | + [40.57] | $\frac{1}{2}$ | 15.5465 | 15.4985 | 0252 | + 19.50 |
| 2 | 53.1201 | ..... | ..... | ..... | 2 | 15.4467 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 45.2864 | ..... | ..... | ..... | 1 | 11.9188 | 11.8757 | 0223 | + 16.70 |
| 1 | 45.2824 | 45.2686 | 0399 | + 32.26 | 2 | 11.5523 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 27.1653 | 27.4323 | 0197 | - 17.10 | | | | | |

Weighted mean..... + 22.85
 V_d - 15.95
 V_d - .23
 Curvature..... - .28

Radial velocity..... + 6.4

 α CORONÆ BOREALIS, 1894.1908, Sept. 19.
G. M. T. 12^h 02^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0180 | ..... | ..... | ..... | 2 | 45.3163 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 72.8619 | 72.8515 | 0133 | - 19.30 | $\frac{1}{2}$ | 45.2773 | 45.2346 | 0041 | - 4.28 |
| 2 | 72.4620 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.4673 | 27.4000 | 0126 | - 10.94 |
| $\frac{1}{2}$ | 54.7725 | ..... | ..... | ..... | 2 | 27.3142 | ..... | ..... | ..... |
| 2 | 53.9865 | 53.9545 | 0153 | - [17.51] | $\frac{1}{2}$ | 11.9190 | 11.8336 | 0178 | - 13.33 |
| $\frac{1}{2}$ | 53.1454 | ..... | ..... | ..... | 2 | 11.5926 | ..... | ..... | ..... |

Weighted mean..... - 11.96
 V_d - 14.58
 V_d - .22
 Curvature..... - .28

Radial velocity..... 27.0

SESSIONAL PAPER No. 25a

 α CORONÆ BOREALIS, 1895.1908. Sept. 19.
G. M. T. 12^h 17^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73·0038 | | | | 2 | 45·2814 | | | |
| $\frac{1}{2}$ | 72·8573 | 72·8633 | ·0015 | -2·18 | 1 | 45·2429 | 45·2351 | ·0036 | 3·76 |
| 2 | 72·4388 | | | | $\frac{1}{2}$ | 27·4293 | 27·4118 | ·0008 | -0·69 |
| 2 | 54·7388 | | | | 2 | 27·2643 | | | |
| $\frac{1}{2}$ | 53·9565 | 54·9580 | ·0118 | -[13·58] | $1\frac{1}{2}$ | 11·8895 | 11·8595 | ·0081 | +6·07 |
| 2 | 53·1120 | | | | 2 | 11·5373 | | | |

Weighted mean..... + 1·26
 V_a -14·58
 V_d -·22
 Curvature..... -·28

Radial velocity..... -13·8

 α CORONÆ BOREALIS, 1896.1908. Sept. 19.
G. M. T. 12^h 30^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54·7526 | | | | $1\frac{1}{2}$ | 45·2619 | 45·2371 | ·0046 | -1·67 |
| $\frac{1}{2}$ | 53·9992 | 53·9889 | ·0191 | +[21·98] | 1 | 27·4389 | 27·3969 | ·0157 | -13·63 |
| 2 | 53·1219 | | | | 2 | 27·2889 | | | |
| 2 | 45·2984 | | | | | | | | |

Weighted mean..... -6·26
 V_a -14·58
 V_d -·22
 Curvature..... -·28

Radial velocity..... -21·3

 α CORONÆ BOREALIS, 1897.1908. Sept. 19.
G. M. T. 12^h 42^mObserved by J. S. PLASKETT.
Measured by J. B. CANNON.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73·0197 | | | | 2 | 45·3094 | | | |
| $\frac{1}{2}$ | 72·8669 | 11·8573 | ·0075 | -10·88 | $1\frac{1}{2}$ | 45·2797 | 45·2439 | ·0052 | +5·43 |
| 2 | 72·4537 | | | | 1 | 27·4750 | 27·4097 | ·0629 | -2·52 |
| 2 | 54·7572 | | | | 2 | 27·3122 | | | |
| $\frac{1}{2}$ | 53·9924 | 53·9731 | ·0033 | +[3·80] | 1 | 11·9309 | 11·8492 | ·0022 | -1·65 |
| 2 | 53·1352 | | | | 2 | 11·5892 | | | |

Weighted mean..... -0·37
 V_a -14·58
 V_d -·22
 Curvature..... -·28

Radial velocity..... -15·5

9-10 EDWARD VII., A. 1910

 α CORONÆ BOREALIS, 1949.1908. Nov. 1.
G. M. T. 10^h 41^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 1 | 72.9672 | | | | 1 | 45.3092 | | | |
| $\frac{1}{4}$ | 72.8800 | 72.9220 | .0572 | -82.99 | $\frac{1}{4}$ | 45.2928 | 45.2928 | .0185 | +19.31 |
| 1 | 54.7508 | | | | | | | | |

Weighted mean +39.88

 V_a - 38 V_d - 27

Curvature - 28

Radial velocity +38.9

 α CORONÆ BOREALIS, 1950.1908. Nov. 1.
G. M. T. 10^h 58^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 48.7674 | | | | 2 | 27.3286 | | | |
| 1 | 45.3178 | 45.3118 | .0631 | +65.87 | $\frac{1}{4}$ | 12.6368 | 11.9236 | .0722 | +54.07 |
| $\frac{1}{4}$ | 27.5393 | 27.4850 | .0724 | +62.84 | 1 | 11.6326 | | | |

Weighted mean +63.40

 V_a - 38 V_d - 27

Curvature - 28

Radial velocity -62.5

 α CORONÆ BOREALIS, 1951.1908. Nov. 1.
G. M. T. 11^h 14^mObserved by } J. B. CANNON.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 45.3028 | | | | 1 | 45.3170 | 45.2878 | .0491 | +51.26 |

Velocity +51.26

 V_a - 38 V_d - 27

Curvature - 28

Radial velocity 50.3

SESSIONAL PAPER No. 25a

OBSERVING RECORD AND DETAILED MEASURES OF δ AQUILÆ.

P. — PLASKETT.
H. — HARPER.
C. — CANNON.
Pl. — PARKER.
T. — TRIBBLE.

RECORD OF SPECTROGRAMS.

| STAR. | No. of Negative. | Camera. | Plate. | Date. | Middle of Exposure. G. M. T. | Duration. | Hour Angle at enl. | TEMPERATURE. | | | | Slit Width. | Seeing. | Observer. | | | |
|------------------|------------------|---------|--------|-------|---------------------------------|-----------|--------------------------|--------------|------|------------|------|-------------|-----------|-----------|-----------------|-----------------|---|
| | | | | | | | | Room. | | Prism Box. | | | | | | | |
| | | | | | | | | Beg. | End. | Beg. | End. | | | | | | |
| 1906. | | | | | | | | Fahrenheit. | | Centigrade | | | | | | | |
| δ Aquilæ. | 368 | .. | Seed | 27 | Aug. | 6 17 | 35 | 85 | 2 | 55W. | 71.0 | 69.4 | 27.7 28.0 | .001 | Good... | H | |
| " | 377 | .. | " | R. | " | 15 15 | 40 | 70 | 1 | 07W. | 68.2 | 66.0 | 25.6 25.6 | .001 | " | H | |
| " | 382 | .. | " | " | " | 24 15 | 45 | 90 | 2 | 15W. | 64.0 | 62.1 | 22.8 22.9 | .001 | Fair.... | H | |
| " | 380 | .. | " | " | Sept. | 10 15 | 30 | 60 | 2 | 50W. | 69.0 | 67.0 | 26.7 26.7 | .001 | Good.... | H | |
| " | 399 | .. | " | " | " | 27 14 | 45 | 60 | 3 | 15W. | 60.0 | 59.6 | 21.8 21.8 | .001 | " | H | |
| " | 413 | .. | " | " | 27 | Oct. | 23 13 | 45 | 90 | 4 | 10W. | 50.3 | 46.2 | 15.1 15.3 | .001 | Dancing | H |
| 1907. | | | | | | | | Centigrade | | | | | | | | | |
| " | 803 | IL | " | " | May | 31 19 | 04 | 25 | | 35E. | 12.6 | 12.6 | 18.7 18.7 | .001 | Good.... | P | |
| " | 818 | " | " | " | June | 10 19 | 13 | 20 | | 15W. | 12.4 | 12.1 | 17.8 17.8 | .0012 | " | P | |
| " | 904 | " | " | " | July | 2 18 | 12 | 24 | | 40W. | 13.5 | 14.0 | 17.0 17.0 | .0014 | " | H | |
| " | 923 | " | " | " | " | 8 18 | 02 | 25 | | 55W. | 20.2 | 20.1 | 22.3 22.2 | .0012 | Poor to fair... | P | |
| " | 930 | " | " | " | " | 9 16 | 33 | 30 | | 30E. | 21.5 | 20.9 | 25.0 25.0 | .0012 | Good.... | H | |
| " | 938 | " | " | " | " | 10 16 | 30 | 30 | | 28E. | 22.6 | 22.4 | 24.5 24.5 | .0012 | Fair to poor... | P | |
| " | 966 | " | " | " | " | 25 16 | 30 | 60 | | 48W. | 21.5 | 21.5 | 28.0 27.8 | .0014 | Poor.... | H | |
| " | 980 | " | " | " | Aug. | 3 14 | 40 | 30 | | 45E. | 19.5 | 19.5 | 24.0 24.1 | .0012 | " | P | |
| " | 982 | " | " | " | " | 5 16 | 38 | 28 | 1 | 10W. | 17.6 | 17.6 | 21.0 21.0 | .0012 | Fair to poor... | P | |
| " | 1034 | " | " | " | Sept. | 6 15 | 44 | 41 | 2 | 35W. | 18.3 | 18.0 | 21.0 20.5 | .0012 | Fair.... | T | |
| " | 1049a | " | " | " | " | 18 13 | 56 | 47 | 1 | 42W. | 14.0 | 12.5 | 17.1 17.1 | .0014 | " | T | |
| " | 1049b | " | " | " | " | | | | | | | | | | | | |
| 1908. | | | | | | | | | | | | | | | | | |
| " | 1543 | " | " | " | May | 18 20 | 06 | 30 | 0 | 00 | 15.5 | 15.0 | 23.4 23.4 | .0016 | Hazy.... | H | |
| " | 1550 | " | " | " | " | 22 20 | 34 | 42 | | 39W. | 19.0 | 19.0 | 25.0 25.0 | .0017 | Fair.... | H | |
| " | 1575 | " | " | " | June | 3 20 | 01 | 40 | | 45W. | 13.0 | 12.5 | 18.3 18.3 | .0015 | " | H | |
| " | 1584 | " | " | " | " | 5 20 | 35 | 40 | 1 | 30W. | 14.0 | 14.3 | 24.4 24.4 | .0016 | Not good | P ¹ | |
| " | 1633 | " | " | " | " | 24 18 | 31 | 37 | | 40W. | 19.0 | 19.0 | 27.5 27.5 | .0015 | Good.... | H | |
| " | 1642 | " | " | " | " | 26 18 | 52 | 55 | 1 | 20W. | 17.6 | 17.5 | 30.2 30.0 | .0016 | " | P ¹ | |
| " | 1650 | " | " | " | " | 27 18 | 09 | 35 | | 30W. | 19.5 | 19.1 | 23.6 23.4 | .0014 | " | P | |
| " | 1660 | " | " | " | July | 3 18 | 35 | 50 | | 25W. | 20.5 | 20.1 | 25.1 25.1 | .0016 | Fair.... | HP ² | |
| " | 1678 | " | " | " | " | 8 18 | 10 | 40 | 1 | 15W. | 17.0 | 17.5 | 21.6 21.6 | .0015 | Good.... | C-H | |
| " | 1690 | " | " | " | " | 10 18 | 35 | 45 | 1 | 55W. | 21.1 | 20.5 | 27.5 28.0 | .0016 | " | P ¹ | |
| " | 1695 | " | " | " | " | 11 18 | 27 | 35 | 1 | 45W. | 26.0 | 25.4 | 29.8 29.7 | .0015 | Fair.... | P | |
| " | 1703 | " | " | " | " | 13 18 | 52 | 45 | 2 | 25W. | 18.2 | 18.0 | 23.0 23.0 | .0015 | Good.... | P ¹ | |
| " | 1753 | " | " | " | " | 31 16 | 41 | 32 | 1 | 10W. | 19.5 | 19.5 | 26.0 25.9 | .0015 | " | P ¹ | |
| " | 1754 | " | " | " | " | 31 17 | 17 | 34 | 1 | 48W. | 19.5 | 19.0 | 25.9 25.6 | .0015 | " | H | |
| " | 1768 | " | " | " | Aug. | 5 18 | 05 | 40 | 2 | 55W. | 20.8 | 20.5 | 26.7 26.5 | .0015 | " | P-C | |
| " | 1783 | " | " | " | " | 15 17 | 38 | 30 | 3 | 05W. | 18.0 | 17.6 | 22.5 22.4 | .0015 | Fair.... | P | |
| " | 1837 | " | " | " | " | 27 15 | 03 | 35 | 1 | 20W. | 18.0 | 17.0 | 23.2 23.0 | .0015 | Good.... | C | |

9-10 EDWARD VII. A. 1910

♂ AQUILE 368.

1906. Aug. 15.
G. M. T. 17° 35"Observed by | W. E. HARPER.
Measured by |

| Wt. | Mean of Settings. | Computed Wave Lengths. | Corrected Wave Lengths. | Normal Wave Lengths. | Displace- ment. | Velocity. |
|-----|-------------------------|------------------------------|-------------------------------|----------------------------|--------------------|-----------|
| 3 | S 68° 3790 | 4528 798 | ..... | ..... | ..... | ..... |
| 3 | 65° 3512 | 4494 626 | ..... | 738 | ..... | ..... |
| 1 | 64° 1176 | 4480 972 | (88) | 400 | 460 | -26 76 |
| 2 | 63° 6677 | 4476 194 | ..... | 185 | ..... | ..... |
| 2 | 62° 7948 | 4466 791 | ..... | 727 | ..... | ..... |
| 1 | 61° 5939 | 4454 023 | 973 | 552 | 579 | 39 63 |
| 3 | S 56° 8911 | 4404 927 | ..... | ..... | ..... | ..... |
| 2 | 54° 6445 | 4383 756 | ..... | 729 | ..... | ..... |
| 3 | 50° 0285 | 4340 237 | 184 | 634 | 450 | 31 05 |
| 3 | 48° 4614 | 4325 992 | ..... | 939 | ..... | ..... |
| 3 | S 46° 4500 | 4308 081 | ..... | ..... | ..... | ..... |
| 1 | 45° 4172 | 4299 044 | ..... | 674 | ..... | ..... |
| 3 | 44° 8605 | 4294 217 | ..... | 391 | ..... | ..... |
| 2 | 44° 3248 | 4289 601 | 642 | 032 | 390 | -27 22 |

Weighted mean. - 31 16
 V_d 10 00
 V_d 16
Curvature 50

Radial velocity..... -41 8

♂ AQUILE 377.

1906. Aug. 15.
G. M. T. 15° 40"Observed by | W. E. HARPER.
Measured by |

| Wt. | Mean of Settings. | Computed Wave Lengths. | Corrected Wave Lengths. | Normal Wave Lengths. | Displace- ment. | Velocity. |
|-----|-------------------------|------------------------------|-------------------------------|----------------------------|--------------------|-----------|
| 2 | S 70° 1969 | 4549 642 | ..... | ..... | ..... | ..... |
| 2 | 70° 1460 | 4549 039 | 039 | 642 | 603 | -39 73 |
| 1 | 68° 8403 | 4533 723 | 753 | 168 | 415 | 27 43 |
| 3 | 68° 4118 | 4528 757 | ..... | 798 | ..... | ..... |
| 2 | 65° 4082 | 4494 722 | ..... | 738 | ..... | ..... |
| 2 | 64° 1638 | 4481 013 | 953 | 400 | 447 | 29 90 |
| 2 | 63° 7291 | 4476 277 | ..... | 185 | ..... | ..... |
| 1 | 63° 0706 | 4469 152 | 062 | 545 | 485 | 32 36 |
| 2 | 62° 8551 | 4466 835 | ..... | 727 | ..... | ..... |
| 1 | 58° 1412 | 4417 700 | 670 | 038 | 358 | 24 95 |
| 3 | S 56° 8682 | 4404 927 | ..... | ..... | ..... | ..... |
| 2 | 54° 6973 | 4383 606 | ..... | 720 | ..... | ..... |
| 3 | 50° 0813 | 4340 115 | 184 | 634 | 450 | 31 05 |
| 3 | 48° 5181 | 4325 926 | ..... | 939 | ..... | ..... |
| 3 | S 46° 5100 | 4308 081 | ..... | ..... | ..... | ..... |
| 2 | 44° 9317 | 4294 348 | ..... | 391 | ..... | ..... |
| 1 | 44° 9073 | 4294 138 | ..... | 391 | ..... | ..... |
| 1 | 44° 3830 | 4289 632 | 590 | 032 | 442 | -30 85 |

Weighted mean - 30 89
 V_d 13 62
 V_d 19
Curvature 50

Radial velocity..... -45 2

SESSIONAL PAPER No. 25a

♂ AQUILÆ 382.

1906. Aug. 24.
G. M. T. 15^h 43^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Computed Wave Lengths. | Corrected Wave Lengths. | Normal Wave Lengths. | Displace- ment. | Velocity. |
|-----|-------------------------|------------------------------|-------------------------------|----------------------------|--------------------|-----------|
| 2 | 70 1122 | 4549 520 | | 642 | | |
| 1 | 70 1029 | 4549 410 | 530 | 903 | 375 | -24 71 |
| 3 | S 68 3400 | 4528 798 | | | | |
| 1 | 67 7987 | 4522 566 | 558 | 855 | 297 | 19 60 |
| 1 | 65 9371 | 4501 472 | | 565 | | |
| 2 | 65 3329 | 4494 735 | | 738 | | |
| 1 | 64 0791 | 4480 926 | 930 | 400 | 470 | 31 44 |
| 2 | 63 6431 | 4476 176 | | 185 | | |
| 2 | 62 7647 | 4466 688 | | 727 | | |
| 1 | 59 7630 | 4435 058 | 078 | 450 | 372 | 25 14 |
| 2 | S 56 7937 | 4404 927 | | | | |
| 1 | 56 3165 | 4400 188 | 188 | 738 | 560 | 37 45 |
| 1 | 55 7715 | 4394 808 | 804 | 286 | 482 | 32 87 |
| 2 | 54 6357 | 4383 715 | | 720 | | |
| 1 | 53 7124 | 4374 809 | 821 | 103 | 282 | 19 31 |
| 2 | 50 0145 | 4340 120 | 134 | 634 | 500 | 34 50 |
| 2 | 48 4534 | 4325 930 | | 939 | | |
| 1 | 47 9225 | 4321 164 | | | | |
| 2 | S 46 4482 | 4308 081 | 164 | | | |
| 2 | 44 8650 | 4294 280 | | 301 | | |
| 1 | 44 8327 | 4294 002 | 018 | 301 | 283 | 19 78 |
| 2 | 44 3189 | 4289 578 | 596 | 032 | 436 | -30 52 |

Weighted mean -27 54

 V_a -16 98 V_d -12

Curvature 50

Radial velocity 45 1

♂ AQUILÆ 380.

1906. Sept. 10.
G. M. T. 15^h 30^mObserved by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Computed Wave Lengths. | Corrected Wave Lengths. | Normal Wave Lengths. | Displace- ment. | Velocity. |
|-----|-------------------------|------------------------------|-------------------------------|----------------------------|--------------------|-----------|
| 1 | 65 2901 | 4494 811 | | 738 | | |
| 1 | 64 0719 | 4481 396 | 360 | 400 | 040 | - 2 67 |
| 1 | 63 6037 | 4476 296 | | 185 | | |
| 2 | 54 5817 | 4383 730 | | 720 | | |
| 1 | 49 9026 | 4339 632 | 620 | 040 | 020 | - 1 38 |
| 3 | 48 3953 | 4325 945 | | 939 | | |

Weighted mean -2 00

 V_a -23 26 V_d -19

Curvature 28

Radial velocity -25 0

9-10 EDWARD VII., A. 1910

1906, Sept. 27.
G. M. T. 14^h 45^m

♂ AQUILÆ 399.

Observed by } W. F. HARPER.
Measured by }

| Wt. | Mean of Settings. | Computed Wave Lengths. | Corrected Wave Lengths. | Normal Wave Lengths. | Displace- ment. | Velocity. |
|-----|-------------------------|------------------------------|-------------------------------|----------------------------|--------------------|-----------|
| 3 | 70.1090 | 4549.618 | | 642 | | |
| 1 | 68.7363 | 4533.425 | 432 | 419 | .013 | - 0.85 |
| | S 68.3316 | 4528.798 | | | | |
| 3 | 65.3312 | 4494.755 | | 738 | | |
| 2 | 64.7742 | 4488.581 | 573 | 495 | .078 | + 5.21 |
| 1 | 64.1215 | 4481.405 | 405 | 400 | .005 | + 0.33 |
| 3 | 63.6427 | 4476.178 | | 785 | | |
| 3 | 62.7675 | 4466.710 | | 727 | | |
| 1 | 62.3372 | 4462.093 | 100 | 165 | .056 | - 3.75 |
| 2 | 62.0765 | 4459.309 | | 301 | | |
| 1 | 61.1665 | 4449.662 | 676 | 785 | .109 | - 7.33 |
| 1 | 58.0743 | 4417.705 | 695 | 884 | .189 | - 12.81 |
| | S 56.8037 | 4404.927 | | | | |
| 1 | 55.8229 | 4395.202 | 210 | 201 | .009 | + 0.61 |
| 1 | 54.6149 | 4383.677 | | 720 | | |
| 1 | 53.6987 | 4370.905 | | 144 | | |
| 2 | 50.6504 | 4340.559 | 564 | 634 | .070 | - 4.83 |
| 2 | 48.4750 | 4325.930 | | 939 | | |
| | S 46.4725 | 4308.081 | | | | |
| 2 | 44.8957 | 4294.319 | | 301 | | |
| 2 | 44.3930 | 4280.984 | 964 | 632 | .068 | - 4.75 |
| 2 | 42.1961 | 4271.329 | 305 | 325 | .020 | - 1.40 |

Weighted mean..... - 2.68

 V_a - 25.74 V_d - .22

Curvature..... - .50

Radial velocity..... - 29.0

1906, Oct. 23.
G. M. T. 13^h 45^m

♂ AQUILÆ 413.

Observed by } W. E. HARPER.
Measured by }

| Wt. | Mean of Settings. | Computed Wave Lengths. | Corrected Wave Lengths. | Normal Wave Lengths. | Displace- ment. | Velocity. |
|-----|-------------------------|------------------------------|-------------------------------|----------------------------|--------------------|-----------|
| 1 | 70.1315 | 4549.642 | 642 | 642 | .000 | 0.00 |
| 1 | S 70.1315 | 4549.642 | | | | |
| 2 | 68.3595 | 4528.840 | | 798 | | |
| 1 | 65.3580 | 4494.715 | | 738 | | |
| 2 | 64.1318 | 4481.159 | 190 | 400 | .210 | - 14.04 |
| 1 | 63.6731 | 4476.145 | | 185 | | |
| 3 | S 56.8482 | 4404.927 | | | | |
| 2 | 54.6954 | 4383.707 | | 720 | | |
| 1 | 53.7352 | 4374.423 | 439 | 628 | .189 | - 12.94 |
| 1 | 50.1309 | 4340.528 | 540 | 640 | .100 | - 6.90 |
| 3 | 48.5209 | 4325.938 | | 939 | | |
| 3 | S 46.5280 | 4308.081 | | | | |
| 2 | 46.4975 | 4307.813 | 813 | 623 | .210 | - 14.61 |

Weighted mean..... - 10.04

 V_a - 26.88 V_d - .25

Curvature..... - .50

Radial velocity..... - 37.7

SESSIONAL PAPER No. 25a

 δ AQUILÆ 803.1907. May 31.
G. M. T. 19^h 04^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8154 | | | | $\frac{1}{2}$ | 45.9607 | .9592 | .0280 | 29.45 |
| 1 | 57.7707 | .7847 | .0421 | -50.68 | 2 | 45.2762 | | | |
| 2 | 54.7232 | | | | 1 | 45.1958 | .1938 | .0449 | 46.87 |
| 1 | 53.9416 | .9516 | .0182 | 20.94 | 2 | 43.5392 | | | |
| 2 | 53.1061 | | | | 2 | 37.9741 | | | |
| 2 | 48.7682 | | | | 1 | 37.2332 | .2192 | .0696 | 66.73 |
| 1 | 48.6938 | .6958 | .0682 | 75.36 | 1 | 27.3962 | .3422 | .0704 | -61.10 |
| 1 | 47.4378 | .4383 | .0321 | 34.34 | 2 | 27.2954 | | | |

Weighted mean - 47.92

 V_a +18.24 V_d + .07

Curvature - .28

Radial velocity - 29.9

 δ AQUILÆ 818.1907. June 10.
G. M. T. 19^h 13^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8253 | | | | 1 | 45.9704 | .9304 | .0568 | 59.75 |
| 1 | 57.7820 | .7780 | .0488 | -58.75 | 2 | 45.3146 | | | |
| 2 | 54.7558 | | | | 1 | 45.2333 | .1923 | .0464 | 48.44 |
| 2 | 48.8030 | | | | 2 | 43.5841 | | | |
| 1 | 48.7360 | .7034 | .0606 | 65.75 | 1 | 27.4760 | .3520 | .0606 | -52.60 |
| 1 | 47.4522 | .4162 | .0542 | 57.99 | 2 | 27.3713 | | | |

Weighted mean - 57.21

 V_a +14.68 V_d 0.00

Curvature - .28

Radial velocity - 42.8

9-10 EDWARD VII., A. 1910

♂ AQUILE 904.

1907. July 2.
G. M. T. 18^h 12^mObserved by J. W. E. HARPER.
Measured by J.

| Wt. | Mean of Settings. | Computed Wave Lengths. | Corrected Wave Lengths. | Normal Wave Lengths. | Displace- ment. | Velocity. |
|-----|-------------------------|------------------------------|-------------------------------|----------------------------|--------------------|-----------|
| 3 | 72.9426 | 4864.756 | | 943 | | |
| 2 | 72.7683 | 4860.608 | .837 | 927 | .690 | -42.57 |
| 2 | 72.3857 | 4851.637 | | 686 | | |
| 1 | 57.8055 | 4550.333 | | 642 | | |
| 1½ | 57.7888 | 4550.031 | .332 | 642 | 310 | 20.43 |
| 1½ | 54.6165 | 4483.099 | | 413 | | |
| 1½ | 53.9383 | 4481.751 | .050 | 400 | 350 | 23.41 |
| 2 | 52.2394 | 4452.897 | | 180 | | |
| 3 | 48.7760 | 4396.316 | | 382 | | |
| 1 | 48.7398 | 4395.740 | .820 | 286 | 466 | 31.78 |
| 1½ | 47.4500 | 4375.754 | .774 | 107 | 333 | 22.88 |
| 2 | 45.2578 | 4342.183 | | 162 | | |
| 1 | 45.2205 | 4341.168 | .108 | 634 | 526 | 36.29 |
| | 42.1262 | 4295.425 | | 290 | | |

Weighted mean - 24.85

V_a + 5.63V_d04

Curvature - .28

Radial velocity - 19.5

♂ AQUILE 923.

1907. July 8.
G. M. T. 18^h 02^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7604 | | | | 2 | 45.3152 | | | |
| 1 | 53.9708 | .9458 | .0240 | -27.62 | 1 | 45.2452 | .2042 | .0345 | 36.01 |
| 2 | 53.1390 | | | | 2 | 38.0093 | | | |
| 1½ | 52.4227 | .3947 | .0201 | 22.73 | 1 | 37.3176 | .2651 | .0237 | 22.72 |
| 2 | 52.2767 | | | | 2 | 35.4883 | | | |
| 2 | 48.8029 | | | | 1 | 27.4678 | .3798 | .0328 | -28.47 |
| 1 | 45.9830 | .9440 | .0400 | 42.08 | 2 | 27.3349 | | | |

Weighted mean 30.63

V_a + 2.96V_d07

Curvature - .28

Radial velocity - 28.0

SESSIONAL PAPER No. 25a

♄ AQUILÆ 930.

1907. July 9.
G. M. T. 16^h 33^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 57 8333 | | | | 1 | 48 7412 | 7360 | 0280 | 30 40 |
| 1 | 57 8169 | 8129 | 0139 | 16 73 | 1 | 47 4795 | 4670 | 0034 | 03 63 |
| 2 | 54 7487 | | | | 2 | 45 2875 | | | |
| 1 | 53 9750 | 9680 | 0018 | 02 07 | 1 | 45 2244 | 2104 | 0283 | 29 54 |
| 2 | 53 1198 | | | | 2 | 57 9870 | | | |
| 2 | 48 7812 | | | | 1 | 37 2898 | 2620 | 0238 | 25 70 |

Weighted mean - 17 98

 V_a + 2 54 V_d 08

Curvature - 28

Radial velocity - 15 6

♄ AQUILÆ 938.

1907. July 10.
G. M. T. 11^h 30^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 59 8376 | | | | 2 | 42 1585 | | | |
| 2 | 58 6448 | 6188 | 0209 | +25 41 | 1 | 41 8098 | 7338 | 0778 | -78 26 |
| 2 | 57 8325 | | | | 2 | 38 0165 | | | |
| 1 | 57 8362 | 8167 | 0161 | -19 38 | $\frac{1}{2}$ | 36 5035 | 4365 | 0597 | -56 77 |
| 2 | 54 7745 | | | | 2 | 35 4998 | | | |
| 2 | 48 8114 | | | | 2 | 30 9556 | | | |
| $\frac{1}{2}$ | 47 4796 | 4351 | 0353 | -38 47 | $\frac{1}{2}$ | 30 8842 | 8082 | 0674 | -60 52 |
| 2 | 45 3240 | | | | 1 | 27 4150 | 3270 | 0856 | -74 30 |
| 1 | 45 2632 | 2128 | 0255 | -26 62 | 2 | 27 3430 | | | |
| 1 | 44 2754 | 2239 | 0148 | -15 28 | 2 | 22 6567 | | | |
| 2 | 43 5880 | | | | $\frac{1}{2}$ | 22 6152 | 5153 | 0791 | -65 49 |

Weighted mean - 20 40

 V_a + 2 18 V_d 00

Curvature - 28

Radial velocity - 18 5

9-10 EDWARD VII., A. 1910

1907, July 25.
G. M. T. 16^h 20^m δ AQUILÆ 966.Observed by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.7903 | ..... | ..... | ..... | 2 | 45.2612 | ..... | ..... | ..... |
| 1 | 57.7957 | .8227 | .0041 | -04.93 | $\frac{1}{2}$ | 45.2242 | .2252 | .0135 | 14.09 |
| 2 | 54.7201 | ..... | ..... | ..... | 2 | 43.5371 | ..... | ..... | ..... |
| 1 | 53.9306 | .9601 | .0097 | 11.16 | $\frac{1}{2}$ | 27.4259 | .3856 | .0267 | -23.17 |
| 2 | 53.0970 | ..... | ..... | ..... |  |  |  |  |  |

Weighted mean.... -11.57
 V_a -4.53
 V_d -.02
Curvature..... -.28
Radial velocity... -16.5

1907, Aug. 3.
G. M. T. 14^h 40^m δ AQUILÆ 980.Observed by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59.8416 | ..... | ..... | ..... | $\frac{1}{2}$ | 46.0142 | .3765 | .0100 | -10.52 |
| $\frac{1}{2}$ | 59.0484 | .0185 | .0222 | -27.10 | 2 | 45.3113 | ..... | ..... | ..... |
| 2 | 57.8562 | ..... | ..... | ..... | 1 | 15.2599 | .2292 | .0168 | 17.53 |
| 1 | 57.8448 | .8178 | .0090 | 10.83 | $\frac{1}{2}$ | 44.2852 | .2468 | .0130 | 13.42 |
| 2 | 54.7701 | ..... | ..... | ..... | 2 | 43.5768 | ..... | ..... | ..... |
| 1 | 53.9962 | .9672 | .0026 | -02.99 | 1 | 41.8349 | .7965 | .0387 | 38.93 |
| 2 | 48.8045 | ..... | ..... | ..... | $\frac{1}{2}$ | 27.4712 | .3986 | .0124 | -10.76 |
| 1 | 47.5163 | .4803 | .0099 | -10.59 | | | | | |

Weighted mean.... -16.87
 V_a -8.53
 V_d -.04
Curvature..... -.28
Radial velocity..... -25.7

SESSIONAL PAPER No. 25a

♂ AQUILÆ 982.

1907. Aug. 5.
G. M. T. 16^h 36^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57.8462 | | | | 1 | 45.2591 | .2231 | .0156 | -16.28 |
| $\frac{1}{2}$ | 57.8389 | .8221 | .0047 | -05.65 | 2 | 44.2644 | .2274 | .0318 | 32.84 |
| 1 | 56.9690 | .9515 | .0140 | 16.68 | 2 | 43.5747 | | | |
| 1 | 56.6945 | | | | 2 | 42.1445 | | | |
| 2 | 48.8909 | | | | 1 | 41.8297 | .7872 | .0441 | 44.36 |
| 1 | 47.5019 | .4698 | .0005 | -00.64 | 2 | 30.9363 | | | |
| $1\frac{1}{2}$ | 46.0152 | .9812 | .0060 | +06.31 | 1 | 30.8976 | .8317 | .0439 | -39.42 |
| 2 | 45.3083 | | | | | | | | |

Weighted mean -19.60

 V_s -9.42 V_d 09

Curvature28

Radial velocity -29.4

♂ AQUILÆ 1034.

1907. Sept. 6.
G. M. T. 15^h 44^mObserved by J. N. TRIBBLE.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59.8664 | | | | 2 | 43.5443 | | | |
| $1\frac{1}{2}$ | 57.8788 | .8313 | .0045 | +05.42 | 1 | 43.4850 | | | |
| 1 | 57.8768 | | | | 2 | 37.9634 | | | |
| 2 | 54.7733 | | | | 1 | 37.2692 | .2682 | .0196 | -18.79 |
| 1 | 54.0167 | .6887 | .0189 | +21.75 | 2 | 35.4242 | | | |
| 2 | 48.7842 | | | | $1\frac{1}{2}$ | 35.1650 | .1650 | .0160 | +15.00 |
| 1 | 48.7878 | .7736 | .0096 | +10.42 | 2 | 30.8659 | | | |
| 2 | 45.2868 | | | | 1 | 30.8385 | .8425 | .0331 | -29.72 |
| 1 | 45.2454 | .2322 | .0065 | -06.78 | 1 | 27.3874 | .3944 | .0182 | -15.79 |

Weighted mean -3.84

 V_s -21.09 V_d 16

Curvature28

Radial velocity -25.4

9-10 EDWARD VII., A. 1910

♂ AQUILÆ 1049 (a).

1907. Sept. 18.
G. M. T. 8^h 56^mObserved by J. N. TRIBBLE.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59·8694 | | | | 2 | 41·3069 | | | |
| 1 | 57·8779 | ·8279 | ·0011 | +01·32 | 2 | 37·9839 | | | |
| 2 | 57·8775 | | | | 1 | 37·2896 | ·2646 | ·0242 | -23·20 |
| 1 | 57·6237 | ·5757 | ·0189 | +22·68 | 1 | 30·8967 | | | |
| $\frac{1}{2}$ | 55·1806 | ·1351 | ·0099 | +11·54 | 1 | 30·8663 | ·8403 | ·0353 | -30·69 |
| $\frac{1}{2}$ | 54·0309 | ·9859 | ·0161 | +18·53 | 1 | 27·4422 | ·4182 | ·0056 | +04·86 |
| 2 | 53·1554 | | | | 2 | 27·2681 | | | |
| 2 | 45·3054 | | | | 2 | 24·8642 | | | |
| $\frac{1}{2}$ | 45·2848 | ·2508 | ·0121 | +12·63 | 1 | 24·8329 | ·8136 | ·0316 | -26·78 |
| 2 | 43·5724 | | | | 2 | 22·5796 | | | |
| 1 | 41·8318 | ·8078 | ·0238 | -23·94 | $\frac{1}{2}$ | 22·5650 | ·5412 | ·0146 | -12·08 |

Weighted mean - 3·66

 V_a -24·00 V_d -·09

Curvature -·28

Radial velocity -28·0

♂ AQUILÆ 1049 (b).

1907. Sept. 18.
G. M. T. 8^h 56^mObserved by J. N. TRIBBLE.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59·8589 | | | | 1 | 42·5064 | ·4794 | ·0314 | -31·80 |
| 1 | 57·8824 | ·8409 | ·0141 | +16·97 | 2 | 42·1333 | | | |
| 2 | 57·8709 | | | | $\frac{1}{2}$ | 41·8333 | ·8073 | ·0243 | -24·44 |
| 1 | 57·6069 | ·5659 | ·0091 | +10·92 | 2 | 41·3082 | | | |
| $\frac{1}{2}$ | 55·1507 | ·1142 | ·0110 | -12·82 | 2 | 37·9828 | | | |
| $\frac{1}{2}$ | 54·0154 | ·9804 | ·0106 | +12·20 | $\frac{1}{2}$ | 37·3204 | ·2984 | ·0006 | +09·20 |
| 2 | 45·3012 | | | | 2 | 24·8630 | | | |
| 1 | 45·2860 | ·2575 | ·0188 | +19·62 | $\frac{1}{2}$ | 24·8351 | ·8173 | ·0279 | -23·63 |
| 2 | 43·5663 | | | | | | | | |

Weighted mean - 1·58

 V_a -24·00 V_d -·09

Curvature -·28

Radial velocity -25·9

SESSIONAL PAPER No. 25a

 δ AQUILÆ 1543.1908, May 18,
G. M. T. 20^h 06^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----------------|-------------------|--------------------------|------------------------------|-----------|---------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 59.8118 | | | | 2 | 45.2857 | | | |
| 1 | 59.6115 | .6090 | .0655 | -80.56 | 1 | 45.1924 | .1819 | .0568 | 59.29 |
| 1 $\frac{1}{2}$ | 57.7867 | .7867 | .0401 | 48.28 | 1 | 44.2082 | .1967 | .0625 | 64.56 |
| $\frac{1}{2}$ | 56.9378 | .9388 | .0297 | 31.82 | 2 | 43.5591 | | | |
| 2 | 56.6665 | | | | 1 | 39.9886 | .9811 | .0352 | 34.35 |
| $\frac{1}{2}$ | 55.0793 | .0793 | .0459 | 53.51 | $\frac{1}{2}$ | 37.2334 | .2134 | .0754 | 72.30 |
| 1 | 53.9367 | .9352 | .0346 | 39.82 | 2 | 37.9775 | | | |
| 2 | 53.1154 | | | | 2 | 30.8437 | .8107 | .0649 | 58.27 |
| 1 $\frac{1}{2}$ | 52.3898 | .3868 | .0280 | 31.66 | $\frac{1}{2}$ | 27.3944 | .3544 | .0582 | -50.50 |
| 1 | 51.6895 | .6860 | .0715 | 80.22 | 2 | 27.2870 | | | |
| 2 | 48.7751 | | | | | | | | |

Weighted mean..... 43.49

 V_d -21.88 V_d - .01

Curvature..... - .28

Radial velocity..... - 21.9

 δ AQUILÆ 1550.1908, May 22,
G. M. T. 20^h 34^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|---------------|-------------------|--------------------------|------------------------------|-----------|-----------------|-------------------|--------------------------|------------------------------|-----------|
| 2 | 59.8566 | | | | 2 | 43.5800 | | | |
| 1 | 53.9680 | .9260 | .0438 | -50.41 | 1 | 43.5040 | .4590 | .0742 | 75.90 |
| 2 | 53.1527 | | | | 2 $\frac{1}{2}$ | 42.4743 | .4268 | .0840 | 85.09 |
| $\frac{1}{2}$ | 52.4092 | .3682 | .0466 | 52.70 | 2 | 37.3817 | | | |
| 1 | 51.7194 | .6799 | .0796 | 89.31 | 1 | 37.3082 | .2552 | .0336 | 32.22 |
| 2 | 50.0548 | | | | $\frac{1}{2}$ | 30.8480 | .7940 | .0816 | 73.26 |
| 2 | 45.3223 | | | | 1 | 27.4542 | .3942 | .0184 | -15.97 |
| 1 | 45.2179 | .1724 | .0663 | 70.54 | 2 | 27.3097 | | | |

Weighted mean..... -60.57

 V_d +20.77 V_d00

Curvature..... - .28

Radial velocity..... - 40.1

9-10 EDWARD VII., A. 1910

♂ AQUILE 1575.

1908. June 3.
G. M. T. 20^h 01^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59·8247 | .. | .. | .. | 2 | 50·0325 | .. | .. | .. |
| 1 | 58·9976 | ·9581 | ·0581 | -71·11 | 1 | 48·7496 | ·7236 | ·0404 | 43·95 |
| 2 | 57·7944 | ·7574 | ·0473 | 57·04 | 2 | 45·3116 | .. | .. | .. |
| 2 | 57·8347 | .. | .. | .. | 1 | 45·2466 | ·2206 | ·0281 | 29·12 |
| 1 | 56·9377 | ·9027 | ·0426 | 50·86 | 1 | 44·2465 | ·2215 | ·0508 | 52·62 |
| 2 | 56·6840 | .. | .. | .. | 2 | 43·9300 | ·9060 | ·0345 | 35·60 |
| 1 | 55·1020 | ·0700 | ·0391 | 45·70 | 2 | 41·3243 | .. | .. | .. |
| 1 | 53·9550 | ·9250 | ·0316 | 35·22 | 1 | 37·3066 | ·2946 | ·0304 | -29·24 |

Weighted mean. -45·35

 V_a +16·94 V_d -·04

Curvature..... -·28

Radial velocity..... -28·7

♂ AQUILE 1575.

1908. June 3.
G. M. T. 20^h 01^mObserved by W. E. HARPER.
Measured by J.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Vel city. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57·7480 | .. | .. | .. | 2 | 45·2208 | .. | .. | .. |
| 2 | 57·7020 | ·7562 | ·0475 | -57·28 | 1 | 45·1452 | ·2080 | ·0307 | 32·14 |
| 1 | 56·8536 | ·9100 | ·0353 | 42·15 | 1 | 44·1533 | ·2163 | ·0560 | 58·02 |
| 2 | 56·5944 | .. | .. | .. | 1 | 42·3660 | ·4300 | ·0406 | 41·29 |
| 1 | 55·0194 | ·0796 | ·0295 | 34·48 | 2 | 42·0584 | .. | .. | .. |
| 2 | 54·6613 | .. | .. | .. | 1 | 41·2210 | ·2860 | ·0337 | 33·83 |
| 1 | 53·8672 | ·9287 | ·0279 | 32·20 | 2 | 39·6969 | .. | .. | .. |
| 2 | 53·0411 | .. | .. | .. | 1 | 38·6841 | ·7516 | ·0318 | 31·07 |
| 1 | 52·2948 | ·3573 | ·0479 | 54·27 | 1 | 37·2157 | ·2842 | ·0408 | 39·25 |
| 2 | 52·1800 | .. | .. | .. | 2 | 30·8595 | .. | .. | .. |
| 2 | 48·7090 | .. | .. | .. | 1 | 30·7894 | ·8774 | ·0585 | 52·77 |
| 1 | 48·6414 | ·7039 | ·0601 | 65·39 | 2 | 22·5580 | .. | .. | .. |
| 1 | 45·8895 | ·9522 | ·0430 | 45·36 | 1 | 22·4961 | ·5909 | ·0619 | -51·56 |

Weighted mean..... -44·84

 V_a +16·94 V_d -·04

Curvature..... 28

Radial velocity..... -28·2

SESSIONAL PAPER No. 25a

 δ AQUILÆ 1584.1908. June 5.
G. M. T. 20^h 35^mObserved by } T. H. PARKER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 1 | 59.8185 | | | | 1 | 45.1990 | .1958 | .0429 | 44.78 |
| 1 | 59.6231 | .6140 | .0605 | -74.41 | 2 | 37.9604 | | | |
| 1 | 57.7645 | .7645 | .0623 | 75.00 | $\frac{1}{2}$ | 37.2349 | .2404 | .0484 | 46.41 |
| 2 | 56.6595 | | | | 2 | 36.4205 | .4255 | .0707 | 67.23 |
| 1 | 53.9346 | .9376 | .0322 | 37.06 | 1 | 35.1146 | .1186 | .0304 | 28.51 |
| 2 | 53.1106 | | | | 2 | 35.4265 | | | |
| 1 | 52.3912 | .3908 | .0240 | 27.14 | $1\frac{1}{2}$ | 30.8236 | .8176 | .0580 | 52.08 |
| $\frac{1}{2}$ | 51.7052 | .7022 | .0553 | 62.04 | 1 | 27.3774 | .3664 | .0462 | 40.10 |
| $1\frac{1}{2}$ | 50.9223 | .9183 | .0348 | 38.69 | 1 | 27.2576 | | | |
| 1 | 50.0435 | | | | $\frac{1}{2}$ | 18.8335 | | .0441 | -35.23 |
| 1 | 48.7062 | .7012 | .0618 | 67.10 | 1 | 18.8776 | | | |
| 2 | 45.2770 | | | | | | | | |

Weighted mean..... -51.40

 V_a +16.22 V_d - .09

Curvature..... - .28

Radial velocity..... -35.5

 δ AQUILÆ 1633.1908. June 24.
G. M. T. 18^h 31^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59.8112 | | | | 1 | 45.2090 | .2005 | .0382 | 39.88 |
| 1 | 57.7871 | .7941 | .0327 | -39.37 | 2 | 44.2642 | | | |
| 2 | 57.8218 | | | | 2 | 41.2960 | | | |
| $\frac{1}{2}$ | 55.4842 | .4887 | .0353 | 41.33 | 1 | 40.4965 | .4875 | .0385 | 38.09 |
| 2 | 54.7384 | | | | 2 | 35.4349 | | | |
| 1 | 53.9350 | .9365 | .0333 | 38.32 | 1 | 35.3907 | .3857 | .0419 | 39.42 |
| 2 | 53.1133 | | | | $\frac{1}{2}$ | 27.3962 | .3792 | .0334 | -28.99 |
| 2 | 45.2822 | | | | 2 | 27.2636 | | | |

Weighted mean..... -37.91

 V_a + 8.74 V_d00

Curvature..... - .28

Radial velocity..... -29.5

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1908. June 26.
G. M. T. 18^h 52^m

♂ AQUILE 1642.

Observed by } T. H. PARKER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59 8137 | | | | 2 | 43 5225 | | | |
| 1 | 59 4942 | | | | $\frac{1}{2}$ | 42 6036 | 6166 | 0230 | 23 34 |
| $\frac{1}{2}$ | 58 9788 | 9748 | 0659 | 80 46 | 2 | 42 1050 | | | |
| 1 | 58 5962 | 5922 | 0057 | 6 93 | $\frac{1}{2}$ | 41 7834 | 7807 | 0352 | 35 41 |
| 2 | 57 8290 | | | | 1 | 40 4726 | 4755 | 0413 | 40 96 |
| 1 | 57 7667 | 7637 | 0631 | 75 97 | 2 | 39 7305 | | | |
| 3 | 56 6748 | | | | 2 | 37 9465 | | | |
| 1 | 53 9205 | 9215 | 0483 | 55 59 | $1\frac{1}{2}$ | 37 6386 | 7096 | 0451 | 43 47 |
| $\frac{1}{2}$ | 53 1059 | | | | $\frac{1}{2}$ | 37 2113 | 2218 | 0670 | 64 25 |
| 1 | 51 6633 | 6683 | 0892 | 100 08 | 2 | 35 4224 | | | |
| $\frac{1}{2}$ | 48 7623 | | | | 2 | 30 8643 | | | |
| 1 | 48 7182 | 7272 | 0368 | 39 94 | 1 | 30 7867 | 7907 | 0849 | 80 64 |
| 3 | 45 2623 | | | | 1 | 27 3707 | 3691 | 0434 | 37 67 |
| 1 | 45 1842 | 1967 | 0420 | 43 84 | 2 | 27 2482 | | | |
| 1 | 44 1888 | 2018 | 0574 | 59 29 | | | | | |

Weighted mean - 47 30

 V_a + 7 87 V_d - 09

Curvature - 28

Radial velocity - 39 8

♂ AQUILE 1650.

1908. June 27.
G. M. T. 18^h 09^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|----------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59 8350 | | | | 1 | 40 5076 | 4860 | 0400 | 39 68 |
| 2 | 57 8130 | 7880 | 0388 | 46 71 | 2 | 39 7571 | | | |
| 2 | 57 8512 | | | | $1\frac{1}{2}$ | 39 6936 | 6736 | 0532 | 52 34 |
| 1 | 56 9804 | 9559 | 0096 | 11 40 | 1 | 38 7283 | 7123 | 0400 | 48 70 |
| 2 | 56 6977 | | | | 3 | 37 9723 | | | |
| 1 | 55 1051 | 0841 | 0411 | 47 92 | 1 | 37 2502 | 2362 | 0526 | 50 44 |
| 2 | 54 7645 | | | | 1 | 36 4387 | 4257 | 0715 | 67 28 |
| $1\frac{1}{2}$ | 53 9517 | 9337 | 0361 | 41 55 | 2 | 35 4463 | | | |
| 3 | 53 1253 | | | | 2 | 30 9004 | | | |
| 1 | 51 6990 | 6860 | 0715 | 80 22 | $1\frac{1}{2}$ | 30 8548 | 8248 | 0508 | 45 70 |
| $\frac{1}{2}$ | 49 3733 | 3583 | 0091 | 10 21 | 1 | 27 3920 | 3600 | 0526 | 45 65 |
| 2 | 48 7901 | | | | 2 | 27 2785 | | | |
| 1 | 48 7440 | 7270 | 0370 | 40 14 | $\frac{1}{2}$ | 24 8214 | 7912 | 0554 | 46 86 |
| 2 | 45 2955 | | | | 1 | 24 1079 | 0789 | 0543 | 45 12 |
| 2 | 45 2045 | 1835 | 0532 | 57 62 | 2 | 24 8754 | | | |
| 1 | 44 2292 | 2077 | 0515 | 53 19 | 2 | 22 5904 | | | |
| 3 | 43 5514 | | | | 1 | 22 5118 | 4782 | 0786 | 65 08 |
| 2 | 42 1240 | | | | 1 | 18 8332 | 7823 | 0609 | 48 65 |
| 1 | 41 2768 | 2558 | 0414 | 41 40 | 2 | 18 8943 | | | |
| $\frac{1}{2}$ | 40 7092 | 6882 | 0610 | 60 79 | | | | | |

Weighted mean - 48 20

 V_a + 7 54 V_d - 04

Curvature - 28

Radial velocity 41 0

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♂ AQUILÆ 1660.

1908. June 27.
G. M. T. 18^h 06^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59.8256 | | | | 2 | 45.2745 | | | |
| 1 | 57.7919 | 7829 | 0070 | - 8.42 | 1½ | 45.2107 | 2097 | 0290 | 30.27 |
| 2 | 57.8327 | | | | 1 | 44.2220 | 2215 | 0377 | 38.94 |
| ½ | 56.9519 | 9499 | 0206 | 24.55 | 1 | 41.7726 | 7741 | 0575 | 57.84 |
| 2 | 56.6750 | | | | 2 | 41.2848 | | | |
| 2 | 54.7459 | | | | 2 | 41.2964 | | | |
| 1 | 53.9418 | 9398 | 0300 | 34.53 | 1 | 39.0028 | 9838 | 0325 | 31.75 |
| 1 | 53.7290 | 7215 | 0360 | 40.39 | 2 | 37.9669 | | | |
| 1 | 48.7544 | 7579 | 0079 | 8.57 | 1 | 37.2796 | 2726 | 0162 | -15.55 |
| 2 | 48.7663 | | | | 2 | 35.4331 | | | |

Weighted mean..... -29.35

V_a..... + 7.66V_d..... 00

Curvature..... - 28

Radial velocity..... 21.9

♂ AQUILÆ 1678

1908. July 8.
G. M. T. 18^h 10^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59.8006 | | | | 2 | 43.5657 | | | |
| ½ | 58.9967 | 0037 | 0370 | -45.21 | 2 | 41.8142 | 7845 | 0471 | 47.38 |
| 1 | 58.5482 | 5552 | 0427 | 51.88 | 2 | 41.3185 | | | |
| 1 | 57.7767 | 7837 | 0431 | 51.89 | 2 | 37.9962 | | | |
| 2 | 57.8125 | | | | 1½ | 37.7667 | 7297 | 0250 | 24.10 |
| 1 | 56.9345 | 9415 | 0240 | 28.60 | 1½ | 37.2799 | 2429 | 0459 | 44.01 |
| 2 | 56.6620 | | | | 2 | 35.4685 | | | |
| 1 | 53.9232 | 9322 | 0376 | 43.27 | 2 | 30.9250 | | | |
| 2 | 53.1017 | | | | 1 | 30.8610 | 8064 | 0692 | 62.14 |
| 2 | 53.1317 | | | | 1 | 27.4311 | 3611 | 0515 | 44.70 |
| 1 | 51.7239 | 7039 | 0536 | 60.13 | 2 | 27.3166 | | | |
| 1 | 48.7590 | 7370 | 0270 | 29.29 | 2 | 24.9101 | | | |
| 2 | 48.7919 | | | | 1½ | 24.8730 | 8080 | 0372 | 31.50 |
| 1 | 47.4680 | 4434 | 0270 | 28.89 | 2 | 22.6292 | | | |
| 2 | 45.3027 | | | | 1½ | 22.5788 | 5063 | 0505 | 41.81 |
| 1½ | 45.2398 | 2138 | 0249 | 25.99 | 2 | 18.9394 | | | |
| 1 | 44.2427 | 2157 | 0435 | 44.93 | ½ | 18.9050 | 8090 | 0335 | -26.76 |

Weighted mean..... -38.83

V_a..... + 2.80V_d..... - 09

Curvature..... - 28

Radial velocity..... - 36.4

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♂ AQUILE 1680.

1908. July 10.
G. M. T. 1^h 37^mObserved by } T. H. PARKER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 59 8492 | | | | 2 | 45 2276 | 2006 | 0321 | 33.51 |
| 1 | 57 8233 | 7873 | 0395 | -47.56 | 2 | 44 2779 | | | |
| 2 | 57 8653 | | | | 2 | 44 2522 | 2336 | 0256 | 26.44 |
| 2 | 55 1478 | 1183 | 0089 | 8.04 | 2 | 43 5578 | | | |
| 2 | 53 9789 | 9519 | 0179 | 20.60 | 1 | 43 5248 | 5653 | 0279 | 24.59 |
| 2 | 54 7702 | | | | 2 | 39 7623 | | | |
| 1 | 53 6528 | 6260 | 0415 | 47.60 | 1 | 38 7677 | 7407 | 0116 | 11.29 |
| 2 | 53 1388 | | | | 1 | 37 7768 | 7483 | 0161 | -15.52 |
| 1 | 47 4598 | 4377 | 0327 | 34.98 | 2 | 37 9904 | | | |
| 2 | 45 2945 | | | | | | | | |

Weighted mean..... -27.41

 V_d +1.71 V_d - .12

Curvature..... - .28

Radial velocity... .. - 26.1

♂ AQUILE 1695.

1908. July 11.
G. M. T. 1^h 27^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displacement in Revolutions. | Velocity. |
|-----|-------------------|--------------------------|------------------------------|-----------|-----|-------------------|--------------------------|------------------------------|-----------|
| 2 | 59 8527 | | | | 2 | 45 3050 | | | |
| 1 | 59 6739 | 6354 | 0391 | -48.13 | 2 | 45 2435 | 2215 | 0172 | 17.95 |
| 1 | 59 0715 | 0335 | 0396 | 48.39 | 2 | 44 2905 | | | |
| 1 | 57 8545 | 8185 | 0083 | 11.19 | 2 | 44 2539 | 2224 | 0368 | 37.97 |
| 2 | 57 8587 | | | | 2 | 42 1319 | | | |
| 2 | 56 9778 | 9428 | 0233 | 27.77 | 1 | 41 8032 | 7749 | 0567 | 57.04 |
| 2 | 56 7102 | | | | 2 | 39 7632 | | | |
| 1 | 55 1281 | 0941 | 0311 | 36.26 | 2 | 39 7632 | | | |
| 2 | 54 7768 | | | | 2 | 30 9112 | | | |
| 1 | 53 9813 | 9473 | 0225 | 25.89 | 1 | 30 8476 | 8146 | 0610 | 54.74 |
| 2 | 53 1442 | | | | 1 | 27 4370 | 3990 | 0136 | 11.80 |
| 1 | 52 4120 | 3790 | 0358 | 40.48 | 2 | 27 2825 | | | |
| 1 | 51 7425 | 7085 | 0490 | 54.97 | 2 | 18 8835 | | | |
| 2 | 48 8042 | | | | 1 | 18 8525 | 8124 | 0310 | -24.8 |
| 1 | 47 4810 | 4485 | 0219 | 23.43 | | | | | |

Weighted mean..... -35.50

 V_d +1.26 V_d - .12

Curvature..... - .28

Radial velocity... .. -34.6

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1908, July 13.
G. M. T. 18^h 52^m

♂ AQUILÆ 1703.

Observed by } T. H. PARKER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59.8090 | ..... | ..... | ..... | 2 | 37.9609 | ..... | ..... | ..... |
| $\frac{1}{2}$ | 57.7842 | 7832 | 0436 | -52.49 | 1 | 37.2499 | 2469 | 0419 | 40.18 |
| $\frac{1}{2}$ | 56.9494 | 9484 | 0171 | 20.38 | 2 | 30.8904 | ..... | ..... | ..... |
| 2 | 54.7423 | ..... | ..... | ..... | 1 | 30.8531 | 8331 | 0425 | 38.15 |
| $\frac{1}{2}$ | 45.2766 | ..... | ..... | ..... | 1 | 27.4061 | 3769 | 0357 | 30.98 |
| $\frac{1}{2}$ | 45.1916 | 1896 | 0491 | 51.26 | 2 | 27.2758 | ..... | ..... | ..... |
| 2 | 43.5362 | ..... | ..... | ..... | 2 | 22.5816 | ..... | ..... | ..... |
| 1 | 43.4567 | 4587 | 0745 | 76.36 | 1 | 22.5331 | 5083 | 0485 | 39.77 |

Weighted mean..... -43.25

V_a -0.36

V_d -16

Curvature..... -28

Radial velocity..... -43.3

♂ AQUILÆ 1753.

1908, July 31.
G. M. T. 16^h 41^m

Observed by } T. H. PARKER.
Measured by }

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 30.8945 | ..... | ..... | ..... | 2 | 22.5725 | ..... | ..... | ..... |
| 1 | 30.8828 | 8588 | 0168 | -15.08 | 1 | 22.5388 | 5231 | 0387 | 32.04 |
| $\frac{1}{2}$ | 27.4102 | 3822 | 0304 | 26.38 | 2 | 18.8774 | ..... | ..... | ..... |
| 2 | 27.2757 | | | | 1 | 18.8637 | | 0137 | -10.94 |

Weighted mean..... -22.81

V_a -7.60

V_d -09

Curvature..... -28

dial velocity..... -30.7

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♂ AQUILÆ 1754.

1908, July 31,
G. M. T. 17^h 17^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7652 | | | | 2 | 43.5520 | | | |
| 2 | 53.9794 | 9574 | 0124 | 14.27 | 2 | 37.9742 | | | |
| 2 | 53.1334 | | | | 1 | 37.2646 | 2496 | 0402 | 38.55 |
| 2 | 48.7862 | | | | 2 | 30.8961 | | | |
| 1 | 47.4588 | 4418 | 0286 | 30.60 | 1 | 30.8566 | 8346 | 0420 | 37.71 |
| 1 | 45.9683 | 9533 | 0307 | 32.29 | 1 | 27.4200 | 3950 | 0176 | 15.27 |
| 2 | 45.2930 | | | | 2 | 27.2709 | | | |
| 1 | 45.2278 | 2128 | 0259 | 27.03 | | | | | |

Weighted mean..... -26.25

 V_a -7.61 V_d -12

Curvature..... -28

Radial velocity..... -34.2

♂ AQUILÆ 1754.*

1908, July 31,
G. M. T. 17^h 17^mObserved by W. E. HARPER.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|-----|-------------------------|--------------------------------|--------------------------------------|-----------|-----|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 54.7189 | | | | 1 | 45.1899 | 2129 | 0258 | 26.93 |
| 1 | 53.9370 | 9575 | 0124 | 14.15 | 1 | 44.2025 | 2255 | 0337 | 34.81 |
| 2 | 53.0936 | | | | 2 | 43.5112 | | | |
| 2 | 52.3557 | 3772 | 0376 | 42.52 | 2 | 37.9405 | | | |
| 2 | 48.7477 | | | | 1 | 37.2294 | 2504 | 0384 | 36.82 |
| 2 | 48.6982 | 7212 | 0428 | 46.48 | 1 | 27.3766 | 3883 | 0240 | 20.84 |
| 2 | 47.4122 | 4352 | 0352 | 37.66 | 2 | 27.2349 | | | |
| 2 | 45.2530 | | | | | | | | |

Weighted mean..... -36.05

 V_a -7.61 V_d -12

Curvature..... -28

Radial velocity..... -44.0

*Check measurement.

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δ AQUILÆ 1768.

1908, Aug. 5,
G. M. T. 18^h 05^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 59 8186 | ... | ... | ... | 1 | 45 9871 | 9876 | 0036 | 3 78 |
| 1 | 57 8102 | 8077 | 0191 | 22 99 | 2 | 45 2749 | ... | ... | ... |
| 2 | 57 8271 | ... | ... | ... | 1 | 45 2148 | 2168 | 0219 | 22 86 |
| 2 | 54 7437 | ... | ... | ... | 1 | 44 2346 | 2376 | 0216 | 22 31 |
| $\frac{1}{2}$ | 53 9784 | 9784 | 0086 | 9 89 | 2 | 43 5328 | ... | ... | ... |
| 2 | 53 1097 | ... | ... | ... | 1 | 41 7874 | 7924 | 0392 | 39 43 |
| $\frac{1}{2}$ | 52 4313 | 4303 | 0155 | 17 53 | 2 | 41 2791 | ... | ... | ... |
| 2 | 52 2541 | ... | ... | ... | 2 | 30 8758 | ... | ... | ... |
| 2 | 48 7696 | ... | ... | ... | $\frac{1}{2}$ | 27 3845 | 3779 | 0361 | 31 33 |
| 1 | 48 7376 | 7361 | 0279 | 30 29 | 2 | 27 2532 | ... | ... | ... |

Weighted mean - 19 51

 V_a 9 77 V_d 19

Curvature 28

Radial velocity - 29 7

δ AQUILÆ 1783.

1908, Aug. 15,
G. M. T. 17^h 38^mObserved by J. S. PLASKETT.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 57 8126 | ... | ... | ... | 2 | 45 2802 | ... | ... | ... |
| 1 | 57 8193 | 8023 | 0245 | 29 49 | 1 | 45 2457 | 2404 | 0020 | 2 08 |
| 2 | 54 7335 | ... | ... | ... | $\frac{1}{2}$ | 44 2265 | 2205 | 0387 | 39 97 |
| 1 | 53 9473 | 9573 | 0125 | 14 38 | 2 | 43 5434 | ... | ... | ... |
| 2 | 53 0905 | ... | ... | ... | 1 | 41 3061 | 2951 | 0021 | 2 10 |
| $\frac{1}{2}$ | 52 4002 | 4072 | 0070 | 8 58 | $\frac{1}{2}$ | 40 5358 | 5258 | 0021 | 2 08 |
| 2 | 52 2469 | ... | ... | ... | 2 | 37 9743 | ... | ... | ... |
| $\frac{1}{2}$ | 51 7060 | 7129 | 0455 | 51 05 | 1 | 37 2659 | 2499 | 0389 | 37 30 |
| 1 | 49 3467 | 3487 | 0213 | 23 25 | 2 | 30 9025 | ... | ... | ... |
| 1 | 48 7663 | ... | ... | ... | 1 | 29 8983 | 8643 | 0105 | 9 31 |
| $\frac{1}{2}$ | 48 7345 | 7360 | 0280 | 30 38 | $\frac{1}{2}$ | 27 4506 | 4116 | 0010 | 0 86 |
| 1 | 47 4838 | 4828 | 0124 | 13 26 | 2 | 27 2858 | ... | ... | ... |
| $\frac{1}{2}$ | 45 9813 | 9773 | 0073 | 7 67 | ... | ... | ... | ... | ... |

Weighted mean - 14 85

 V_a - 13 84 V_d 22

Curvature 28

Radial velocity - 29 2

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♂ AQUILÆ 1837.

1908. Aug. 27.
G. M. T. 15^h 03^mObserved by J. B. CANNON.
Measured by T. H. PARKER.

| Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. | Wt. | Mean of Settings. | Corrected Star Settings. | Displace- ment in Revolutions. | Velocity. |
|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|---------------|-------------------------|--------------------------------|--------------------------------------|-----------|
| 2 | 73.0183 | | | | 2 | 45.2880 | | | |
| $\frac{1}{2}$ | 72.8513 | .8430 | .0218 | -31.63 | 1 | 45.2372 | .2232 | .0155 | -16.18 |
| 2 | 72.4532 | | | | 1 | 44.2386 | .2264 | .0328 | 33.91 |
| 2 | 59.8129 | | | | 2 | 43.5517 | | | |
| 1 | 57.8288 | .8283 | .0015 | +1.80 | 1 | 41.8679 | .7949 | .0367 | 36.92 |
| 2 | 54.7500 | | | | 1 | 37.9771 | | | |
| 1 | 53.9747 | .9667 | .0031 | -3.56 | 1 | 37.3070 | .2925 | .0037 | +3.54 |
| 2 | 53.1197 | | | | 2 | 30.9679 | | | |
| $\frac{1}{2}$ | 51.7273 | .7173 | .0402 | -45.10 | $\frac{1}{2}$ | 30.8756 | .8386 | .0370 | 33.22 |
| 2 | 48.7819 | | | | 1 | 30.4141 | .3751 | .0375 | -32.55 |
| 1 | 47.4976 | .4846 | .0142 | +15.19 | 2 | 30.2857 | | | |
| $\frac{1}{2}$ | 46.0043 | .9915 | .0041 | +4.31 | | | | | |

Weighted mean -20.95

 V_a -18.18 V_d - .69

Curvature - .28

Radial velocity -39.5

APPENDIX 3.

REPORT OF THE CHIEF ASTRONOMER, 1909.

MERIDIAN WORK AND TIME SERVICE

BY

R. M. STEWART, M.A.

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APPENDIX 3.

REPORT OF R. M. STEWART, M.A., ON MERIDIAN WORK AND TIME SERVICE.

OTTAWA, March 31, 1909.

W. F. KING, Esq., LL.D., C.M.G.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR.—I have the honour to report as follows on the work carried out under my charge during the past fiscal year.

A great part of the year has been taken up with work in connection with the fitting up of the Transit Annex, including the reconstruction of the piers, and with tests and alterations of the Meridian Circle. As will be seen below, the latter has proved to be defective in many respects, necessitating a great deal of work in the alterations required before it can be made to perform creditably; among the most important and laborious of the operations were the renewing of the pivots and the truing up of the planes of the circles; further alterations still remain to be made. The usual amount of observation and computation has been done for determination of clock error, more particularly in connection with the operations carried on in the field for determination of longitudes. The question of personal equation was considered, and a special series of observations made in an attempt to discover the laws which it followed. The differences of personal equation found were in some cases comparatively large; the personal equations of at least two of the observers appeared to be due to a tendency always to set the movable wire asymmetrically with respect to a star image when estimating a bisection; in the case of one observer this error of bisection amounted to over a second of arc. The time service has been maintained as in the past, and has been extended to include the Mint and the Archives Building. An analysis was made of the rate of the Standard Sidereal Clock; an account of this is given in Appendix A below.

THE TRANSIT ANNEX.

The Transit Annex, which is located at the western end of the main building, consists of two rooms, the Transit Room and the Meridian Circle Room. The former is connected to the main building by two doors, one opening into the Chronograph Room, and through it into the Time Room, the other communicating with the main hall-way. In it are situated two piers for the portable astronomical transits belonging to the Observatory, the western one of which is also provided with two collimator piers. The inside dimensions of this room are 21 ft. 4 in. in the meridian by 21 ft. 9 in. in the prime vertical. The Meridian Circle Room, situated to the west of the former, communicates with it by two doors. It is 34 ft. 3 in. by 15 ft. 6 in., and contains the piers for the Meridian Circle and its two collimators; the instrument is situated somewhat to the south of the centre of the room.

The walls of the building are of stone, containing a number of louvred windows to allow circulation of air between the outside walls and the inner lining. The latter is of galvanized iron, and covers the whole of the outer walls except the observing slits. The roof is a flat concrete one; between it and the galvanized iron ceiling is

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an air-space of about two feet, through which the outer air circulates freely by means of a number of small louvred openings. Ventilation of the room itself, when the observing slits are closed, can be controlled by a number of shafts which pierce the walls, terminating just above the floor in registers which may be opened or closed as desired. The observing slits, which extend downward to within three feet of the floor, are three feet in width; they are closed by vertical doors in the walls, and by shutters on the roof. The opening mechanism for these, which was installed during the past winter, is described below.

As mentioned in my last report, the Meridian Circle piers had suffered upheaval during the winter of 1907-8, shortly after the instrument had been mounted. During the period between the early part of January and the end of March the level error changed from about ten seconds to nearly six minutes of arc. During the next two weeks it rapidly decreased to about two and a half minutes, and thereafter continued decreasing with a gradually diminishing rate; by the middle of May it had reached a value of about one minute. As the graduated circles had been returned to the makers for repairs there was no convenient means of measuring the change of nadir point, *i.e.*, the angular displacement of the piers in the meridian; it also, however, was no doubt considerable. The collimator piers were also displaced by a number of minutes. The two field-transit piers and the two collimator piers in the Transit Room fared even worse, having all been broken across in the basement a few feet above the floor.

The trouble was evidently due to the action of frost; if further confirmation were needed, it was supplied by an examination of the earth beneath the basement of the Transit Room, which was found to have been saturated with water and frozen. A drain had been provided to carry away surplus water, but the system of drainage was not sufficiently thorough. It was also evident that the foundations of the piers were not sufficiently protected. It was decided that the only satisfactory remedy lay in the reconstruction of all the piers, sinking their bases several feet deeper into the earth, and providing a system of drainage as thorough as could be installed. The matter was taken up by the Department of Public Works, and the demolition of the old piers—an undertaking of considerable magnitude in itself—was begun in May.

It had been previously decided that the azimuth marks for the Meridian Circle should depend on the same principle as those designed by Sir David Gill for the Cape Observatory, the primary marks consisting of lenses fixed some distance underground to ensure stability, while above would be movable marks capable of being adjusted accurately over the optical centres of the underground lenses. A similar arrangement would be required in the case of the collimator piers, to ensure the stability of the long-focus collimating lenses which form a part of the azimuth-mark system. As the original collimator piers had not been designed with this end in view, the necessity of reconstruction afforded an opportunity of so altering the design as to facilitate the introduction of this principle. It was necessary also in this connection to consider the disposition of the collimators. If these were placed in a horizontal line it was found that it would be impossible to obtain a line of sight under them upon azimuth marks at a sufficient distance; nor was it considered advisable to raise the azimuth marks to the horizontal line and, by rendering them invisible, use them as collimators, on account of the height to which it would then be necessary to build the azimuth piers. It was decided finally to do away with the south collimator, using the azimuth mark in its place, and placing a mounting for the other collimator on the north pier, above the collimating lens of the north azimuth mark. This was also advantageous in another respect, since the southern pier, being required only for the long-focus collimating lens, need not extend so far towards the Meridian Circle, thus increasing the range of reflection observations towards the south; the north collimator would not interfere with those towards the north, on account of its greater distance from the telescope. It is possible, however, that the north collimator may also finally be dispensed with;

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if, as seems likely, the azimuth marks should prove sensibly stable for considerable periods, it will be possible to control the collimation by readings on them, in conjunction with occasional reversals of the Meridian Circle. Determinations of flexure might also be made by means of the azimuth marks, by an interchange of eye and object ends of the telescope. Should this arrangement prove possible it will be of advantage; the lenses of the collimators being of only $4\frac{1}{2}$ inches aperture, the full aperture of the Meridian Circle is not made use of in readings upon them, and it is perhaps doubtful whether the line of collimation so obtained will coincide exactly with that depending on full aperture.

The footings of the reconstructed piers extend $16\frac{1}{2}$ feet below the level of the floor. Beneath the transit room is a basement with a concrete floor, which lies 10 feet below the upper floor, so that the transit piers extend $6\frac{1}{2}$ feet underground; the Meridian Circle and collimator piers, on the other hand, are surrounded with earth to a height of about 10 feet. All the piers are surrounded at the base by drains of broken stone. It was my wish to have these drains continued to within a few inches of the surface, so that there could be no doubt as to the thorough drainage of the piers throughout their whole height; the Public Works Department, however, decided that drainage around the bases would be sufficient, and it was so done.* On account of the depth to which the piers were sunk, it was impossible to lead these drains to the sewage system; accordingly a special concrete cistern of about 1,000 gallons capacity was built below the level of the piers and the drains were led into this; a pipe leading from the cistern to a motor pump serves to empty it as often as necessary. A float connected to a light rod has been so arranged that the top of the rod may be flush with the basement floor when the cistern is empty; the length of rod projecting through the floor gives a measure of the depth of water in the cistern. The amount of water which collects in the cistern at certain seasons is remarkable; on several occasions this spring, immediately after or during a prolonged heavy rain, it has been filled overnight; this circumstance, coupled with the fact that during periods of dry weather comparatively little water is collected, points to surface water as the source of the accumulation. It would appear that the surface drainage flows down beside the outside walls of the building and so under the foundations, often in considerable quantities; this being the case, there would appear to be serious danger not only of finally blocking up the broken stone drains by accumulated silt, but also of undermining the foundations of the Transit House. This danger could probably be avoided by building a suitable drain to surround the three exposed walls of the building.

The parts of the two collimator piers below the floor are similar. The footings are nine feet by six, the longer side being in the east-west direction. The western part of each pier is penetrated by a vertical pit three feet square, to allow access to the underground lens which will serve as the fixed mark; this part of the pier terminates some six feet below the level of the floor of the Meridian Circle Room, and the opening is covered by two hatchways, between which is packed mineral wool. The main part of the pier tapers upwards to the floor, where it measures three and a half feet in the meridian by two and a half in the prime vertical. Through the centre of this is a vertical shaft about six inches in diameter, extending down to the level of the pit previously mentioned, into which it opens by a small arch. At the bottom of the arch the underground lens will be fastened firmly to the concrete, with space underneath for a basin of mercury. Access is had to these when necessary by the pit at the side, while the necessary readings are taken from above through the small shaft.

Above the floor the piers are dissimilar. The northern one, which is intended to support both collimator and long-focus azimuth lens, is built with an overhang to the north, so as to allow as much space as possible to the south for observation of stars by reflection; the dimensions of the top are 5 ft. $4\frac{1}{2}$ in. by 2 ft. 4 in. The southern pier,

* This has since proved to be inadequate.

which will ultimately be required only for the long-focus lens, tapers from the floor to a size of 20 inches by 28 inches at the top. It will also be necessary, however, to fasten a temporary frame-work to the southern pier to support a collimator until the azimuth mark piers shall have been built.

The foundations of the main telescope piers are intended also to carry a pier which rises to the level of the floor, to support the carriage upon which rests the mercury horizon for observation of stars by reflection. In the original pier this had not been included, but it was found that the cement floor was not sufficiently free from vibration to serve the purpose. This part of the pier is, at the floor level, 10 ft. 6 in. in length by 1 ft. 10½ in. in width, extending 3 feet south of the axis of the Meridian Circle, and 7 ft. 6 in. to the north. The foundation is in the form of a cross, with an extreme length of 13 feet, and width of 10 ft. 6 in., tapering upwards to within a foot of the floor, where the size is 10 ft. 6 in. by 8 ft. The two columns supporting the bed-plates of the instrument are 2 ft. 3 in. square at the floor, tapering to 1 ft. 4 in. at the top, which rises to a height of 6 ft. 2 in. from the floor. The inner faces of the piers, which are vertical, are at a distance of 3 ft. 6 in.

In the Transit Room, the two transit piers and the two collimator piers, the latter forming part of the system of the western transit equipment, extend to the same depth as the Meridian Circle piers; as stated above, however, owing to the basement which underlies this part of the building, they are surrounded with earth to a height of only 6½ feet; the concrete cistern above referred to lies immediately to the south of the eastern transit pier. A floor plan of the Meridian Circle Room and Transit Room, showing the positions of the various piers is given in Fig. 1; sections of the piers are shown in Fig. 2 and Fig. 3.

All the piers are protected above the level of the floor by a layer of thick felt; surrounding this, with the interposition of an air-space, is a casing of wood. These casings, as well as the piers themselves, are of course free from the floor; the space between piers and floor, instead of being vacant, is filled with felt. To promote cleanliness, as well as for increased comfort during the winter months, the original concrete floor has been covered by a wooden one.

To exclude snow from the spaces between the inner and outer walls and above the ceiling it was necessary to have winter coverings for the louvred openings. These were made in the fall of 1908 and have worked satisfactorily during the past winter. They consist of frames to fit on the outside of the openings, covered with copper wire gauze of a fairly fine mesh; for protection against accidents this is covered by a somewhat heavy galvanized iron mesh. It has been found that these, while affording a reasonable circulation of air, exclude the greater part of the snow; if a little snow drifts through, it is caught by the louvres and prevented from penetrating to the space inside the walls. To ensure a freer circulation of air during the summer, the frames are removed in the spring.

The roof shutters for covering the observing slit are divided into three sections in the case of the Meridian Circle, and into two in the case of each of the transit slits. An opening mechanism had previously been applied to the central section in the Meridian Circle Room; that for the other six sections was installed during the past winter. The mechanism works on the same principle as that at Greenwich; each section of the shutter is supported by the outer ends of two curved arms which are fastened by keyways on a shaft hung in bearings parallel to the slit; the other ends of these arms carry counterpoises approximately equal in weight to the shutter. Keyed on the shaft is another arm extending horizontally nearly to the wall, and connected by another nearly vertical jointed arm to a winch on the wall, which serves to open or close the shutters by turning a handle. The joint between every two sections is covered by an independent flap, which is raised by either shutter indifferently; the flap is prevented from falling back when open by a flat curved spring which presses against it near the hinge, and starts it down with the shutter when the latter is being closed.

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The vertical wooden wall-shutters, six in number, have been made in two sections, closing respectively the lower and upper halves of the observing slits in the walls. Both sections open outwards; either the upper section alone, or both, may be opened; the lower section, however, can not be opened alone; in general only the upper section need be open, except for reading on azimuth marks. The upper section is controlled by a rod bent at right angles near its upper extremity, and fastened by a flexible joint nearly in the centre of the shutter; when closed the horizontal part of the rod passes over a hook on the shutter and the vertical part springs into place between two hooks on the casement, holding the shutter firmly closed; when open it is held in a similar manner.

The difference of longitude between the middle of the observing slit in the Meridian Circle Room and the pier in the old transit hut was measured January 20, 1909. A theodolite was set up to the south of the old hut and set on the transit wires; the azimuth of a point on the wall of the transit annex was measured from this point and the distance chained. The resulting longitudes of the Meridian Circle and of the centres of the two transit piers, referred to the old pier, are as follows:—

| | | | |
|-----------------------|------------|-----------|-----------|
| Meridian Circle, | 214.9 ft. | | .201 sec. |
| Western transit pier, | 199.9 ft. | | .187 " |
| Eastern transit pier, | 188.65 ft. | | .176 " |

The approximate latitude of the Meridian Circle, as obtained from a few pairs of stars observed in August, 1908, is $45^{\circ} 23' 37''.6$; this may be in error by several tenths of a second.

The positions of the azimuth marks for the Meridian Circle were laid down in the early part of last summer. The line of sight to the north mark passes through the pinery immediately to the north of the Observatory; the pier will be situated just beyond the top of a ridge running in the east-west direction, and within about 30 feet of the road which forms the southern boundary of the city; its distance from the collimating lens will be about 250 feet. It was originally intended to have the south azimuth mark, if possible, at a distance of about 300 feet, situated on the other side of the driveway which runs in a northwest-southeast direction past the western end of the Observatory. As this ground belonged to the Department of Agriculture it was necessary to have its consent to the erection of the mark, and this unfortunately proved impossible. It was therefore necessary to locate the mark on the grounds of the Observatory; as the line of sight of the Meridian Circle crosses the above-mentioned driveway at an angle, the greatest distance obtainable was about 160 feet.

The piers and the buildings to protect them have been planned, but no provision has as yet been made for their erection.

THE MERIDIAN CIRCLE.

No observations were made with the Meridian Circle during the period covered by this report. The year has been occupied with the many alterations which were found necessary before the instrument could be got into condition to do creditable work. There is scarcely an essential part of the instrument which has not required alteration in at least some detail. Much of this work has been done; much still remains to do. It is hoped, however, if the repairs which still remain can be completed in the workshop in time, to be able to begin regular work in both right ascension and declination about the beginning of 1910.

The graduated circles, which had been returned to the makers for repair of damages sustained in shipping, were received in June. They were immediately mounted and their planeness tested by the same method as used previously, as described in my last report. It was found that the extreme deviation of the fixed circle from a true plane at right angles to the axis was now about .001 inch; that of the movable

circle was, however, .006 inch, a quantity large enough to throw the microscopes very slightly out of focus at the extreme points. It was also discovered that on reversing the instrument the microscopes were no longer in focus; in fact, the circles were unsymmetrically fixed on the axis by about one twenty-fifth of an inch; it developed later that this was at least partly due to the fact that in truing up the fixed circle, not only had the band carrying the graduations been turned down but also a cut had been taken off the bearing on the other side of the circle, without any compensating alteration on the movable circle.

To rectify the latter point, it would appear to be immaterial whether the circle were set farther out on the axis, or the end of the pivot shortened, or, what amounts to the same thing, the other pivot lengthened; the desideratum being that the distance from plane of graduations to end of pivot should be the same for both ends. Accordingly, as being the easiest undertaking, a bushing of hardened steel was made to fit into the hollow of the pivot corresponding to the movable circle, carrying a disc of the required thickness which fitted against the end of the pivot. This worked fairly satisfactorily, but as will be seen below, another alternative was adopted later.

With regard to the other error of the circles, which we may for brevity designate the deviation from mean plane, it may be composed of two parts—(1) a divergence of the average plane of the graduations from true perpendicularity to the axis; (2) a deviation of the graduated band itself from the true plane form; the former may be remedied by alteration of the bearing surfaces between circles and axis, the latter only by re-graduation. If p be the perpendicular distance of the object glass of any microscope from the graduated band, and d the distance of the graduation set upon from the centre of the field, then the measured angle will be

$$\theta = \frac{d}{p}.$$

Differentiating with respect to θ and p

$$\delta \theta = - \frac{d}{p^2} \delta p = - \theta \frac{\delta p}{p}.$$

Hence the error in the angle measured by one microscope is proportional to that angle and to δp , which is the deviation from mean plane of the circle at that point. The maximum effective value of θ , provided settings of the telescope are made without regard to the position of the division marks in the field of the microscopes, and provided also that only one division mark is set on for each setting of the telescope, will be the same as the interval between successive graduations, in this case 5'; also the value of p is 2.7 inches. Thus if p be .001 inch, the maximum error arising from this source of an angle measured by one microscope will be .11'. Further, this will be practically a constant error for any particular star, except as influenced by reversal of the instrument and more particularly by alterations of the position of the circle on the axis. If, however, as is practically always the case, angles be measured by a pair of opposite microscopes, the part of this error due to lack of perpendicularity of graduated band and axis will be eliminated, p being of opposite sign for the two microscopes. That part, however, which depends on deviations of the graduations from a true plane, will still remain; if the deviations are due to a simple bend of the circle along a diameter the effect will be reduced, though not eliminated, by reading four microscopes. It may be noted here that the error $\delta \theta$ varies inversely as p ; hence the advantage of long focus microscopes; those on this instrument are probably too short.

All errors arising from deviation from mean plane may be eliminated by setting exactly on division marks, throwing the brunt of the measurement on the declination micrometer. In this case it is sufficient if the circles are nearly enough true that the graduations may be always in focus. This must, however, be qualified by the recollection that focal lengths, &c., vary with temperature; hence it is desirable even in this

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case that the circles should be as true as possible, in order that the necessity of re-focussing may be reduced to a minimum.

Having regard to these facts, it was decided in the first place to attack the adjustment of the movable circle, as being the one most requiring it; it was also decided that the only feasible method lay in scraping the bearings between circle and axis, in conjunction with tests by a surface-plate. In order to save time, since the reconstruction of the piers in the meridian circle room was being proceeded with, it was decided to erect temporary piers outside for the necessary tests, and to shelter them by a wooden hut. In the meantime a special surface plate in the form of a ring was constructed, in order to make the necessary tests for flatness of the bearing on the axis against which the circle was clamped.

As before, the lower southern microscope on the western pier was replaced by a steel rod sliding in bearings, one end of which could be brought into contact with the graduations when desired. A mark on this was set on with the microscope, which had been mounted with its axis perpendicular to the rod. Readings were taken at every 30° around the circle; the latter was then shifted 90° on the axis and the process repeated; the same was done for positions of the circle 180° and 270° from its initial position.

Assume in the first instance that the graduations all lie in one plane; also that the bearing surface on the circle and that against which it engages on the axis are true planes. Let the angle between the axis of the telescope and the normal to the surface of the bearing on the axis be a'' , and let the plane containing these two lines intersect the position of the lower southern microscope when the pointer reading on the fixed circle is φ . Also let the normals to the plane of the graduations and the plane of the circle bearing (on the movable circle) include an angle b'' , and, for the initial position of the movable circle, let χ be the pointer reading on the fixed circle when the plane containing these two normals cuts the lower southern microscope. Then, for the position of the telescope corresponding to a pointer reading θ on the fixed circle, the displacement from its mean position of the graduated band (on the movable circle), as measured by the microscope, will be

$$a \cos (\theta - \varphi) + b \cos (\theta - \chi).$$

Taking a series of readings at intervals of 30° around the circle, and diminishing each by the mean of all, we shall have twelve equations of the form,

$$a \cos (\theta - \varphi) + b \cos (\theta - \chi) = m,$$

θ having the values 0° , 30° , 60° , &c. For the second position of the circle we have twelve equations of the form

$$a \cos (\theta - \varphi) + b \cos (\theta + \frac{\pi}{2} - \chi) = m',$$

and similarly for the two remaining positions. From these 48 equations we may determine a , b , φ and χ with considerable accuracy, thus obtaining a complete knowledge of the magnitude and location of the errors considered. Further, by substituting the values so found in the observation equations, we may from an examination of the residuals determine by how much the circle departs from the plane form.

The first test with the new surface plate showed a high spot at one point on the axis bearing; when this had been scraped off the deviation of the circle was considerably lessened. The first set of measurements after this had been done gave a value of $9''$ for a and about $4''$ for b ; in one position of the circle on the axis this corresponds to a variation of over .002 inch, exclusive of irregularities. It was found also that the circle was distorted by the pressure of the screw collar which holds it against the axis, so that when the collar was forced home the irregularities reached a value of $7''$ on each side of the mean, as against about $4''$ when it was only moderately tight; this was found to be due to the fact that the circle bearing was not a plane; the same was true of the face of the screw collar and the face on the circle against which it bore.

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For these latter, since the only requirement was that they should be plane, one scraping, in conjunction with tests by a surface plate, was sufficient; in the case of the bearings between circle and axis, however, on account of the difficulty of knowing just how much was taken off at a time, it was necessary to proceed by trial, taking care that both surfaces should always be plane when measurements were taken. In this way, after some half dozen trials, the values of *a* and *b* were each reduced to about 1".

Some preliminary measurements had previous to this been made for determination of pivot error; it had been assumed without testing that the pivots were hardened; it was accidentally discovered, however, about the end of August, while the adjustment of the circles was still going on, that this was not the case. Such a serious defect as this had not been anticipated, though considering the many other imperfections of the instrument it should perhaps not have proved surprising.

After consideration, it was decided to turn the pivots down to a smaller size, and to force over them hardened steel bushings of the original diameter (4 inches). We were much handicapped by lack of previous experience in such operations, and by the lack of machines large enough to accommodate the axis, but after several failures have finally succeeded in obtaining pivots which give every promise of being satisfactory.

As the lathe at the Observatory was not large enough for the purpose, the axis was taken to a machine shop in the city, and the original pivots turned down to a diameter of about $3\frac{1}{2}$ inches; they were then carefully ground with a very slight taper, to facilitate the forcing on of the bushings. Here again difficulty was encountered, as nowhere in the city was there a grinder capable of accommodating the instrument; inquiries in Montreal and Toronto were equally unavailing. The grinding was finally done in a lathe, by fastening a small portable motor-driven cutter-grinder in the tool-post of the lathe. The first bushings were made from forgings obtained from a local firm; after turning, boring and hardening these, they were ground inside to the required taper, and outside to very nearly the finished size, and then forced over the ground surfaces on the axis. They were then reground, and finished by using flour emery in a circular lap of gun-metal. Not until this final process was reached was it discovered that the metal was permeated by minute flaws which made the attainment of a perfect surface impossible.

At this stage Messrs. Warner and Swasey, the well known instrument makers of Cleveland, were communicated with; in their reply they very kindly gave a complete description of the processes they employed in finishing pivots. The details of the process were practically the same as had been followed here, with the exception that they advised making the bushings not from forgings, but from blocks cut out of bar steel, to insure as far as possible homogeneity and freedom from strains and flaws. Accordingly a bar of steel was obtained and new bushings made from it; on this occasion the use of the workshop at the Royal Mint, where large lathes were available, was very kindly offered by Mr. Cleave, and was thankfully accepted. Trouble was again experienced with the lapping, it being found impossible to get a satisfactory surface. The Observatory mechanician, Mr. Mackey, who has had long practical experience in all kinds of machine work, finally gave it as his opinion that the difficulty arose from the small inequalities left in the surface by the portable grinder employed, the machine not having sufficient rigidity to ensure an even surface; as a matter of fact this proved in the end to be the case.

One of the machines at the Mint is a large grinder, sufficiently long to carry the meridian circle axis, but capable of swinging only fourteen inches, while the largest diameter of the axis is eighteen inches. This machine Mr. Cleave very readily permitted to be altered by raising the centres to a sufficient height; in fact the work in connection with the alteration was all performed at the Mint, and nearly all by his own workmen. When this had been done, the pivots were re-ground in it, and no further trouble was experienced in the lapping. At the same time, the tapered bearings on which the circles fit, were trued up, as a slight eccentricity with respect to the

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new pivots had been introduced; this made it necessary also to turn a corresponding amount off the faces against which the circles are clamped. During the process a small cut was also taken off the end of one pivot, to eliminate the asymmetry mentioned above in the positions of the circles.

In this connection I wish to express my appreciation of the very great kindness of Mr. Cleave in practically placing his whole workshop at our disposal. Had it not been for his generous offer the work could hardly have been done in Canada.

As stated above, a great deal of work still remains to be done on the instrument. The two bearings on the axis, against which the circles are clamped, will doubtless require to be scraped, as will also the bearing on the fixed circle; this alone will require considerable time. The counterpoises are very unsatisfactory; a weight of about 350 pounds is at present counterpoised through a lever system by 10 pounds; with such a multiplication factor, especially with the arrangement used, the friction is so great as to prohibit effective control of the weight resting on the pivots; new counterpoises will require to be made. The right ascension micrometer, or rather the eye-piece slide driven by it, does not work freely, and will require overhauling. Several of the micrometer slides in the circle microscopes do not work freely; the springs in these are also unsatisfactory. The double spider lines in right ascension and declination micrometers and circle microscopes are at unsuitable and varying distances, and will require to be renewed. Besides these, there are many other details which require attention. The necessary alterations can best be made at the Observatory, where personal supervision will be possible; as, however, the machine shop is always overcrowded with work, it may take considerable time.

The observing couch, which was ordered some time ago, has been received. It is of somewhat different design from the ordinary form, and is intended to afford facility for quick setting in any desired position, together with the possibility of easy adjustment after the observer has taken his place upon it. Four wheels, running upon the same tracks as the reversing carriage, carry a wooden frame-work which in its turn supports a central transverse axis. On the latter is pivoted a light steel frame, which is also supported near one end by two screws connected with the wooden frame-work; by rotating these the frame may be tilted through a small angle in either direction. On the same axis are mounted two movable leaves; each of these is supported near its outer end by two rack sectors which engage pawls fastened to the steel frame; the pawls engage in the racks by their own weight, but may be released by a conveniently placed handle. The slow-motion screws are connected by means of a sprocket chain and bevel gears with two hand-wheels mounted one at each end of the transverse axis. The leaves of the couch can thus be quickly set in the approximate position required by means of the sectors, and after the observer has taken his place upon the couch he can tilt the whole upper frame into the proper position by means of the hand-wheels, which are always within easy reach. This slow motion has been found in practice to be a great convenience.

TRANSIT OBSERVATIONS.

Observations with the portable Cooke transit were conducted during the greater part of the year, as heretofore, in the temporary transit shed at the eastern end of the Observatory. About the end of January, however, the instrument was moved to the new Transit Room and set up on the western pier, where it has since remained. The difference in longitude between the new pier and the old is 199.9 feet, or .187 sec.

Observations were made on 142 nights, involving 281 determinations of clock error, as well as some observations for other purposes; on a number of nights two, and sometimes three, observers worked simultaneously, for determination of personal equation. The observations throughout the summer were principally for the purpose of longitude determinations at different points. As clock exchanges were frequently required with two different stations on the same night, sometimes at intervals of an

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hour or two, it would have been troublesome to arrange the observing so that it would not conflict with the exchanges. For this reason the two features were kept independent throughout the season, a separate chronograph being used for the exchanges; the latter were held at the hours most convenient to the field observers, irrespective of observations or weather conditions at Ottawa; whenever possible two determinations of clock error were made on every night, preferably, but not necessarily, about the time at which the exchanges were held; for nights on which no observations were obtained the clock error was interpolated from the two adjacent nights. This arrangement, which is of course permissible only with a clock of demonstrated reliability, has proved quite sufficiently accurate for all ordinary purposes; in the case of very important stations the interpolation from night to night might perhaps not be advisable; the independence of observations and exchanges is of advantage, especially on nights broken by clouds, in that it frees the observer from the interruptions and delay inseparable from an exchange. The number of exchanges was 156, occupying 116 nights; the observing was divided among Mr. Nugent, Mr. Smith and myself, the greater part being done by the two former. A first computation of the observations was made by Mr. Tobey; they were then recomputed by the observers, and a final check including occasional recomputations was made.

The accuracy of determinations of level error during the summer was not up to standard. Early in the season the tip was broken off the level vial belonging to the transit; as no other good vial was available, and as several months were required before delivery of a new one, it was necessary to seal up the old one and continue using it. Though the mean value of a division was practically unaltered, it was found that the bubble had become rather sluggish and uncertain in its action, and considerable trouble was experienced with measurements of level error during the whole summer. The apparent probable error of a complete determination of level (comprising usually six independent measurements) was .011 sec.; that for 1907 was .006 sec., and for the spring of 1909, after renewal of the vial, .005 sec. This difference has probably quite an appreciable effect on the accuracy of the work.

The fluctuations in azimuth throughout the summer were reasonably small; adjustments in level were, however, frequently necessary; another peculiarity of the level error was its tendency to progressive change during the evening's work, the western end of the instrument usually rising as the evening progressed; usually a compensating change took place in the opposite direction during the day, though the general tendency of movement throughout the summer was in the former direction. The average rate of elevation of the western pivot was .017 sec. (of time) per hour; the rate varied between -.016 sec. and 0.73 sec. per hour, being negative on 16 nights out of 89. There was no apparent connection between change of level and change of temperature during the hours of observation.

The method of observation was that described in my last report; a set consisted of seven or eight southern stars well up towards the zenith, combined with three or four north stars between 70° and 80° declination; the telescope was reversed during the observation of each star; as a rule only one group of observations on each star was taken in each position of the instrument. The star-list used contained all the stars in Newcomb's Fundamental Catalogue between 10° and 40° and between 70° and 80° declination; the places of the Berliner Jahrbuch were used for all stars contained therein; for the other stars the places were taken from the Nautical Almanac, the *Connaissance des Temps* and the *American Ephemeris* without the application of any systematic correction; as the number of such stars was not very large, and as substantially the same list was used for the field observations, any resulting errors in the longitudes deduced would be small.

In the same way as described in my last report, the average discordance between two sets observed on the same night (after allowing for clock-rate) was used as a measure of accuracy; from this quantity the probable error of a single set may be

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deduced as follows:—The chance of an error x occurring in the first set on any particular night is

$$\frac{h}{\pi} \cdot e^{-h^2 x^2} \cdot \delta x,$$

where h is the measure of accuracy, and δx is the smallest quantity measured. Similarly the chance of an error $x + z$ occurring in the second set is

$$\frac{h}{\sqrt{\pi}} \cdot e^{-h^2 (x+z)^2} \cdot \delta x.$$

The chance of both errors occurring on the same night is the product of these quantities; if we take into account the case where an error $x + z$ occurs in the first set and an error x in the second the chance is doubled. Hence the number of pairs of errors x and $x + z$ occurring in N nights is

$$2N \frac{h^2}{\pi} \cdot e^{-h^2 (2x^2 + 2xz + z^2)} \cdot \delta x \cdot \delta z.$$

Hence the number of discordances z (irrespective of sign) occurring in N nights is

$$2N \frac{h^2}{\pi} e^{-\frac{h^2 z^2}{2}} \cdot \delta z \int_{-\infty}^{+\infty} e^{-h^2 (\sqrt{2} \cdot x + \frac{1}{\sqrt{2}} \cdot z)^2} \cdot \delta x$$

$$\text{or } Nh \sqrt{\frac{2}{\pi}} \cdot e^{-\frac{h^2 z^2}{2}} \cdot \delta z.$$

Hence the sum of all discordances is

$$Nh \sqrt{\frac{2}{\pi}} \int_0^{\infty} e^{-\frac{h^2 z^2}{2}} \cdot z \, dz = \frac{N}{h} \sqrt{\frac{2}{\pi}},$$

and if the average discordance be denoted by Δ we have

$$\Delta = \frac{1}{h} \sqrt{\frac{2}{\pi}}.$$

But the probable error $r = \frac{.4769}{h}$; hence $r = .5978 \Delta$.

In the third column of Table I. are given the clock corrections obtained from each set throughout the summer; the fifth column gives the discordance (after allowing for clock rate) in every case where two sets were taken by the same observer on a single night; the average of all the discordances is .033 sec., being practically the same for all three observers; the probable error deduced from this is .0197 sec. The value of Δ deduced in my last report for the old method of observation was .039 sec., corresponding to a probable error of .0233 sec.; as the weight, or efficiency, is inversely proportional to the square of the probable error, the increase of efficiency indicated is 40 per cent; and presumably this has arisen from the alterations in methods of observation and grouping of stars.

As stated above, however, the probable error of the measurement of level was .011 sec. in 1908 as against .006 sec. in 1907 and previous years. If we assume that this effect enters for its full value in the observations of 1908, we should, for a proper comparison, reduce the probable error of a set for the latter year accordingly; that is, we would have a probable error of .0174 sec. for 1908, as against .0233 sec. for previous years, an increase in efficiency of about 80 per cent.

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TABLE I.—TRANSIT OBSERVATIONS IN 1908.

| Date. | Time. | | ΔT | Observer* | Discordance. | T_s |
|--------------|-------|----|------------|-----------|--------------|-------|
| | h | m | s | | | s |
| May 14 | 14 | 50 | 2 434 | N | .033 | 2 355 |
| | 17 | 10 | 2 478 | N | | 2 399 |
| " 15 | 12 | 50 | 2 466 | C S | .013 | 2 466 |
| | 14 | 40 | 2 488 | C S | | 2 488 |
| " 18..... | 13 | 10 | 2 761 | C S | .024 | 2 761 |
| | 14 | 55 | 2 793 | C S | | 2 793 |
| " 20..... | 14 | 45 | 2 960 | C S | .058 | 2 960 |
| | 16 | 30 | 3 026 | C S | | 3 026 |
| " 22..... | 13 | 25 | 3 270 | S | | 3 304 |
| | 16 | 25 | 3 287 | C S | | 3 287 |
| " 27..... | 12 | 50 | 3 843 | C S | .026 | 3 843 |
| | 14 | 40 | 3 878 | C S | | 3 878 |
| June 1..... | 13 | 20 | 4 960 | C S | | 4 960 |
| " 2..... | 13 | 30 | 5 110 | N | .014 | 5 031 |
| | 16 | 05 | 5 102 | N | | 5 023 |
| " 3..... | 14 | 30 | 5 017 | C S | .033 | 5 017 |
| | 16 | 40 | 5 055 | C S | | 5 055 |
| " 4..... | 14 | 15 | 5 250 | N | .017 | 5 171 |
| | 15 | 45 | 5 270 | N | | 5 191 |
| " 5..... | 13 | 40 | 5 231 | C S | .042 | 5 231 |
| | 15 | 55 | 5 278 | C S | | 5 278 |
| " 6..... | 14 | 25 | 5 336 | N | | 5 257 |
| " 8..... | 13 | 45 | 5 323 | C S | | 5 323 |
| " 9..... | 17 | 05 | 5 553 | N | .037 | 5 474 |
| | 19 | 00 | 5 519 | N | | 5 440 |
| " 10..... | 13 | 55 | 5 478 | S | .001 | 5 512 |
| | 15 | 30 | 5 480 | S | | 5 514 |
| " 11..... | 13 | 50 | 5 639 | N | .003 | 5 560 |
| | 15 | 45 | 5 639 | N | | 5 560 |
| " 12..... | 13 | 55 | 5 559 | S | .012 | 5 593 |
| | 15 | 20 | 5 549 | S | | 5 583 |
| " 17..... | 14 | 25 | 5 722 | S | .049 | 5 756 |
| | 15 | 40 | 5 773 | S | | 5 807 |
| " 18..... | 15 | 05 | 5 856 | N | | 5 777 |
| " 20..... | 16 | 00 | 5 913 | N | .079 | 5 834 |
| | 17 | 55 | 5 995 | N | | 5 916 |
| " 21..... | 14 | 40 | 6 149 | N | .026 | 6 070 |
| | 16 | 30 | 6 128 | N | | 6 049 |
| " 22..... | 14 | 45 | 6 120 | C S | .028 | 6 120 |
| | 16 | 05 | 6 151 | C S | | 6 151 |
| " 24..... | 14 | 25 | 6 302 | C S | .077 | 6 302 |
| | 16 | 00 | 6 228 | C S | | 6 228 |
| " 25..... | 14 | 35 | 6 418 | N | .006 | 6 339 |
| | 16 | 20 | 6 416 | N | | 6 337 |

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TABLE I.—TRANSIT OBSERVATIONS IN 1908—*Continued*

| Date. | Time. | | <i>T</i> | Observer.* | Discordance. | <i>T</i> |
|--------------|-------|----|----------|------------|--------------|----------|
| | h. | m. | s. | | | s. |
| June 26..... | 15 | 40 | 6 408 | C S | | 6 408 |
| | 17 | 00 | 6 430 | C S | ·019 | 6 430 |
| " 27..... | 17 | 20 | 6 432 | N | | 6 553 |
| " 28..... | 15 | 00 | 6 649 | S | | 6 683 |
| | 16 | 15 | 6 607 | S | ·045 | 6 641 |
| " 29..... | 14 | 55 | 6 740 | C S | | 6 740 |
| 30..... | 15 | 05 | 6 910 | N | | 6 831 |
| | 17 | 00 | 6 906 | N | ·009 | 6 827 |
| July 1..... | 16 | 00 | 6 869 | C S | | 6 869 |
| | 17 | 50 | 6 855 | C S | ·019 | 6 855 |
| " 3..... | 15 | 15 | 6 963 | C S | | 6 963 |
| | 16 | 35 | 6 990 | C S | ·024 | 6 990 |
| | 18 | 50 | 6 944 | S | | 6 978 |
| | 20 | 00 | 6 961 | S | ·014 | 6 995 |
| " 5..... | 15 | 05 | 7 006 | S | | 7 100 |
| " 6..... | 17 | 50 | 7 110 | C S | | 7 110 |
| " 8..... | 15 | 30 | 7 261 | C S | | 7 261 |
| | 17 | 10 | 7 229 | C S | ·036 | 7 229 |
| " 9..... | 15 | 05 | 7 371 | N | | 7 292 |
| | 17 | 00 | 7 401 | N | ·025 | 7 322 |
| 10..... | 15 | 10 | 7 388 | C S | | 7 388 |
| | 16 | 40 | 7 330 | C S | ·062 | 7 330 |
| " 11..... | 17 | 25 | 7 489 | N | | 7 410 |
| | 18 | 35 | 7 441 | N | ·051 | 7 362 |
| " 12..... | 15 | 40 | 7 423 | S | | 7 457 |
| | 18 | 05 | 7 380 | S | ·049 | 7 414 |
| " 13..... | 18 | 10 | 7 533 | N | | 7 454 |
| | 19 | 25 | 7 514 | N | ·022 | 7 435 |
| " 14..... | 15 | 15 | 7 553 | C S | | 7 553 |
| | 16 | 30 | 7 498 | C S | ·058 | 7 498 |
| " 15..... | 15 | 35 | 7 604 | C S | | 7 6 4 |
| | 18 | 00 | 7 610 | C S | ·000 | 7 610 |
| " 16..... | 15 | 55 | 7 670 | N | | 7 636 |
| | 17 | 35 | 7 593 | N | ·077 | 7 579 |
| " 20..... | 17 | 55 | 7 644 | C S | | 7 644 |
| " 24..... | 16 | 35 | 7 593 | C S | | 7 593 |
| | 17 | 55 | 7 631 | C S | ·038 | 7 631 |
| " 25..... | 16 | 45 | 7 547 | S | | 7 581 |
| | 18 | 10 | 7 534 | S | ·011 | 7 568 |
| " 26..... | 16 | 05 | 7 508 | C S | | 7 508 |
| | 17 | 30 | 7 498 | C S | ·008 | 7 498 |
| " 28..... | 17 | 05 | 7 341 | N | | 7 327 |
| | 19 | 05 | 7 286 | N | ·051 | 7 272 |
| " 29..... | 17 | 15 | 7 271 | C S | | 7 271 |
| | 18 | 40 | 7 263 | C S | ·008 | 7 263 |

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TABLE I.—TRANSIT OBSERVATIONS IN 1908—*Continued.*

| Date. | Time. | | ΔT | Observer.* | Discordance. | ΔT_0 |
|---------|-------|----|------------|------------|--------------|--------------|
| | h. | m. | s | | | s |
| July 30 | 16 | 35 | 7 289 | N | 018 | 7 275 |
| | 18 | 20 | 7 271 | N | | 7 257 |
| " 31 | 16 | 50 | 7 258 | C S | 065 | 7 258 |
| | 18 | 20 | 7 323 | C S | | 7 323 |
| Aug. 2 | 17 | 25 | 7 370 | S | | 7 404 |
| " 5 | 17 | 53 | 7 665 | C S | 088 | 7 665 |
| | 19 | 15 | 7 756 | C S | | 7 756 |
| " 6 | 20 | 50 | 7 701 | N | 030 | 7 687 |
| | 22 | 15 | 7 733 | N | | 7 719 |
| " 7 | 18 | 25 | 7 767 | C S | 044 | 7 767 |
| | 19 | 25 | 7 813 | C S | | 7 813 |
| " 9 | 17 | 40 | 7 986 | S | 050 | 8 020 |
| | 19 | 15 | 7 940 | S | | 7 974 |
| " 11 | 17 | 40 | 8 156 | N | 040 | 8 142 |
| | 19 | 00 | 8 119 | N | | 8 105 |
| " 13 | 18 | 20 | 8 280 | N | 002 | 8 266 |
| | 19 | 55 | 8 286 | N | | 8 272 |
| " 15 | 18 | 55 | 8 336 | N | | 8 322 |
| " 17 | 18 | 50 | 8 404 | C S | 005 | 8 404 |
| | 20 | 05 | 8 411 | C S | | 8 411 |
| " 18 | 19 | 40 | 8 427 | N | | 8 413 |
| " 19 | 18 | 05 | 8 576 | N | 009 | 8 562 |
| | 19 | 20 | 8 509 | N | | 8 495 |
| " 20 | 20 | 05 | 8 546 | C S | 045 | 8 546 |
| | 21 | 10 | 8 591 | C S | | 8 591 |
| " 21 | 18 | 00 | 8 616 | C S | 007 | 8 616 |
| | 19 | 20 | 8 625 | C S | | 8 625 |
| " 22 | 18 | 30 | 8 620 | N | 042 | 8 606 |
| | 19 | 45 | 8 664 | N | | 8 650 |
| " 23 | 21 | 20 | 8 608 | S | | 8 642 |
| " 24 | 17 | 45 | 8 683 | C S | 067 | 8 683 |
| | 19 | 05 | 8 752 | C S | | 8 752 |
| " 25 | 18 | 15 | 8 793 | N | 005 | 8 779 |
| | 19 | 25 | 8 790 | N | | 8 776 |
| " 26 | 20 | 10 | 8 789 | C S | | 8 789 |
| " 27 | 18 | 00 | 8 826 | N | 018 | 8 812 |
| | 19 | 20 | 8 810 | N | | 8 796 |
| " 28 | 19 | 00 | 8 803 | C S | 006 | 8 803 |
| | 20 | 05 | 8 811 | C S | | 8 811 |
| " 30 | 18 | 30 | 8 833 | S | 062 | 8 867 |
| | 19 | 40 | 8 773 | S | | 8 807 |
| " 31 | 18 | 10 | 8 859 | C S | 032 | 8 859 |
| | 19 | 20 | 8 893 | C S | | 8 893 |

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TABLE 1.—TRANSIT OBSERVATIONS IN 1908.—*Continued.*

| Date. | Time. | | ΔT | Observer.* | Discordance. | ΔT . |
|---------------|-------|----|------------|------------|--------------|--------------|
| | h. | m. | s | | | s |
| Sept. 3 | 18 | 15 | 8.986 | N | .031 | 8.972 |
| | 19 | 40 | 9.019 | N | | 9.005 |
| " 4 | 18 | 05 | 9.070 | C S | .037 | 9.070 |
| | 19 | 15 | 9.035 | C S | | 9.035 |
| " 5 | 19 | 40 | 9.076 | N | .029 | 9.062 |
| | 21 | 00 | 9.107 | N | | 9.093 |
| " 6 | 18 | 30 | 9.030 | S | .032 | 9.064 |
| | 19 | 40 | 9.064 | S | | 9.098 |
| " 7 | 19 | 40 | 9.110 | N | .059 | 9.096 |
| | 21 | 05 | 9.171 | N | | 9.157 |
| " 8 | 19 | 55 | 9.199 | C S | .015 | 9.199 |
| | 21 | 05 | 9.186 | C S | | 9.186 |
| " 11 | 20 | 15 | 9.388 | C S | .011 | 9.388 |
| | 21 | 35 | 9.379 | C S | | 9.379 |
| " 12 | 19 | 05 | 9.419 | N | .036 | 9.405 |
| | 20 | 50 | 9.386 | N | | 9.372 |
| " 14 | 19 | 05 | 9.453 | C S | .064 | 9.453 |
| | 20 | 25 | 9.519 | C S | | 9.519 |
| " 16 | 19 | 10 | 9.561 | C S | .064 | 9.561 |
| | 20 | 15 | 9.499 | C S | | 9.499 |
| " 19 | 19 | 10 | 9.676 | N | .035 | 9.662 |
| | 20 | 30 | 9.713 | N | | 9.699 |
| " 20 | 19 | 25 | 9.616 | S | .048 | 9.650 |
| | 20 | 50 | 9.570 | S | | 9.604 |
| " 21 | 19 | 50 | 9.616 | S | .033 | 9.650 |
| " 25 | 20 | 45 | 9.706 | C S | | 9.706 |
| " 29 | 20 | 25 | 9.813 | S | .033 | 9.847 |
| | 21 | 25 | 9.782 | S | | 9.816 |
| Oct. 1 | 20 | 50 | 9.906 | C S | .040 | 9.906 |
| " 2 | 19 | 55 | 9.994 | C S | | 9.994 |
| | 22 | 10 | 9.968 | C S | | 9.958 |
| | 22 | 10 | 9.910 | S | | 9.944 |
| " 3 | 20 | 25 | 9.939 | S | .008 | 9.973 |
| | 21 | 35 | 9.933 | S | | 9.967 |
| " 5 | 21 | 10 | 10.060 | C S | .023 | 10.060 |
| | 22 | 40 | 10.040 | C S | | 10.040 |
| | 22 | 40 | 10.017 | S | | 10.051 |
| " 6 | 20 | 35 | 10.073 | N | .023 | 10.059 |
| | 22 | 05 | 10.099 | N | | 10.085 |
| " 7 | 21 | 00 | 10.076 | C S | .002 | 10.076 |
| | 22 | 20 | 10.081 | C S | | 10.081 |
| " 9 | 19 | 40 | † 366 | C S | .049 | † 366 |
| | 20 | 45 | 417 | C S | | 417 |
| " 11 | 21 | 00 | 276 | S | | 310 |

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TABLE I.—TRANSIT OBSERVATIONS IN 1908.—*Continue I.*

| Date. | Time. | | ΔT | Observer.* | Discordance. | ΔT |
|------------------|-------|----|------------|------------|--------------|------------|
| | h. | m. | s. | | | s. |
| Oct. 12 | 20 | 40 | 400 | C S | | 400 |
| | 22 | 25 | 401 | C S | 002 | 401 |
| | 20 | 40 | 336 | S | | 370 |
| | 22 | 25 | 363 | S | 024 | 397 |
| " 13. | 20 | 45 | 454 | N | | 440 |
| | 22 | 25 | 371 | N | 086 | 357 |
| | 22 | 25 | 390 | S | | 424 |
| " 14 | 21 | 50 | 444 | N | | 430 |
| | 21 | 50 | 456 | S | | 490 |
| " 15 | 21 | 30 | 591 | N | | 577 |
| | 21 | 30 | 520 | S | | 554 |
| Nov. 21 | 0 | 55 | 2 291 | S | | 2 325 |
| | 2 | 35 | 2 382 | S | 088 | 2 416 |
| | 0 | 55 | 2 280 | N | | |
| | 2 | 35 | 2 247 | N | 016 | |
| " 26. | 23 | 50 | 2 952 | N | | |
| | 23 | 50 | 2 988 | C S | | 2 988 |
| " 29. | 0 | 30 | 3 253 | S | | 3 287 |
| | 2 | 20 | 3 259 | S | 002 | 3 293 |
| | 0 | 30 | 3 307 | C S | | 3 307 |
| | 2 | 20 | 3 309 | C S | 002 | 3 309 |
| Dec. 2 | 0 | 20 | 3 664 | C S | | 3 664 |
| | 1 | 50 | 3 611 | C S | 056 | 3 611 |
| | 1 | 50 | 3 516 | N | | |
| " 5... | 23 | 05 | 3 981 | S | | 4 015 |
| | 0 | 55 | 3 994 | S | 009 | 4 028 |
| | 23 | 05 | 3 864 | N | | |
| | 0 | 55 | 3 827 | N | 041 | |
| Mean Discordance | | | | | \pm 033 | |

* The letters used to denote the observers are as follows:—R. M. Stewart, S; D. B. Nugent, N; C. C. Smith, CS.

† On Oct. 9, owing to a blown-out fuse, the winding circuit of the clock failed for a few minutes; though the pendulum continued to swing uninterrupted, the reading of the clock-face was changed.

‡ The personal equation of N had changed between Oct. 15 and Nov. 21; hence the observations of N are not entered in the last column after Nov. 21.

PERSONAL EQUATION.

An examination of the values of clock error for successive days, as given in the third column of Table I., shows that the differences of personal equation are not negligible. This was very clearly seen on plotting the results in a curve, using different coloured inks for each observer; it was also quite noticeable that the personal equation of N had suffered a sudden change between July 13 and July 16. To determine the values of the personal equations the summer was broken up into periods during which the curve appeared most regular; then for any one period the mean of the observations on each night was represented by the observation equation

$$a + bt + ct^2 + e = \Delta T,$$

t being the interval from a fixed epoch, a , b and c arbitrary constants, ΔT the observed clock error, and e the personal equation of the observer referred to the standard obser-

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ver. It will be seen that this amounts to assuming that the clock-rate, during the period considered, varied uniformly with the time; the periods were so chosen, by inspection of the curve, that this condition should be approximately fulfilled; even if this were not the case the deduced values of e would still be trustworthy, provided the work of each observer were distributed fairly uniformly over the whole period. After combining the observation equations and deducing the values of e for N and CS , referred to S as standard, and also of a , b and c , these values were substituted in the observation equations and the residuals formed. As the average of the residuals for those parts of the summer included in the periods considered was .022 sec., the largest being .06 sec., it follows that the observations are fairly well represented by the formula. The relative personal equations derived for each period, with their probable errors, are given in Table II. From these figures it would appear that during June and July the personal equation of CS underwent a gradual progressive change; from a consideration of the observations as a whole, however, and considering the fact that, especially in the first period, the observations of CS were not distributed over the whole period, it was decided to treat the personal equations of CS and of S as constant throughout the season, and to assume (as was evidenced by the clock-curve) a sudden change in that of N about July 15. Combining the results for the whole season on this assumption, the values of personal equation derived are as follows:—

$$CS - S \text{ .034 sec.}$$

$$N - S \text{ .113 sec. up to July 15; afterwards .048 sec.}$$

As will appear below, it seemed likely from some later developments that the absolute personal equation of CS was nearly zero; for this reason the above results were altered so as to make his observations the standard; the corrections to be applied to the clock errors of each observer were then as follows:—

$$S \text{ .034 sec.}$$

$$N - .079 \text{ sec. up to July 15; afterwards } - .014 \text{ sec.}$$

$$CS \text{ .000 sec.}$$

These corrections have been applied to form the last column in Table I.

To obtain the personal equations of the two field observers M^* and J , some additional observations were made, the field observers occupying a hut immediately to the south of the one in which the home observations were taken. The observations with M extended from September 14 to October 14; those with J , who did not return from the field until later, from November 21 to December 5. During a part of this time two of the home observers frequently observed together, in order to strengthen the determination both of their own personal equations and of those of the field observers. This was rendered possible by the fact that the transit used (Cooke I) was fitted with an attachment which caused it to record over every alternate four revolutions (of the micrometer screw) throughout the field; one observer would follow the star over a group of contacts at a considerable distance from the centre of the field, the other over a group somewhat closer; after reversal the same series of observations was repeated in the reverse order; thus the observations of each observer were complete in themselves; the groups of contacts made by each observer were interchanged for alternate stars. Each observer also took an independent series of level readings; as it was found, however, that there was no systematic difference in this regard, the mean of all the level readings was taken in making the reductions.

The observations for M 's personal equation are collected in Table III.; those for that of J in Table IV. It is evident from Table IV. that for the November and December observations the personal equation of N had again suffered a decided change; those of S and CS , however, appear to have remained relatively unchanged; consequently in obtaining the personal equation of J only the observations of S and CS have been used.

* F. A. McDiarmid.

† W. C. Jaques.

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The values of personal equation obtained above for the five observers engaged were applied throughout in the computations for longitude. Though perhaps not as accurate as might be desired, the agreement of the longitudes derived on different nights has been in general improved by their application, and there is at least no doubt of the real existence of personal differences of about the magnitudes indicated. It follows that it is never safe to assume the absence of personal equation with the transit micrometer, as was the tendency for some time after its introduction; though some of the differences involved above are small enough to be neglected except in the most refined work, several of them are of quite appreciable magnitude. They are, however, much smaller than the personal equations ordinarily occurring in key observations.

In considering *à priori* the question of personality with the transit micrometer, it would appear that there are two factors capable of affecting the result. On account of the motion of the star, there may be a tendency always to keep the moveable wire either ahead of or behind the star, irrespective of its apparent direction of motion; the distance between star and wire, expressed in angular measure, might be expected to be somewhat less for the more slowly moving stars, but this tendency would be, to some extent at least, counterbalanced by the greater value (expressed in time) of any particular angular interval for the latter class of stars; thus the tendency would be for the record to be made either too soon or too late by a quantity which might be sensibly the same for stars of all declinations; this is a personal equation of the same kind as the so-called 'reaction-time' in observations by eye and ear or with the telegraphic key, but it might be expected to be smaller. The second factor is the personal error of bisection, by virtue of which an observer may tend always to set the wire either to the right or left of the centre of the star-image which he attempts to bisect; this effect would change sign with the direction of apparent motion, and its absolute value would be proportional to the secant of the declination, changing sign at the zenith and at the pole; it might also be expected to vary with the magnitude. This error is also present in the case of estimation of transits across fixed wires; there is, however, so far as the variation with magnitude is concerned, the difference that in the latter case the tendency is usually to estimate the bisection of a bright star sooner than that of a faint one, irrespective of the direction of motion, while in the case of the transit micrometer, differences of magnitude will presumably simply have the tendency to increase or diminish the error of bisection.

Errors of the first class arise from the motion of the star, but are independent of its direction; those of the second class do not arise from the motion, but (when expressed as corrections to the time of transit) change sign with its apparent direction; the former will affect the time, but not the azimuth; the latter both, but more markedly the azimuth.

It had long ago been noticed by the writer that, for his own observations, it was impossible satisfactorily to combine observations of south stars with those of north stars at both upper and lower culmination; this for the reason that the stars at upper culmination, when combined with the south stars, gave values of clock error and azimuth consistently differing from those derived from the stars at lower culmination. This circumstance was explicable by supposing that the observations were affected by a systematic error of bisection, and by no other hypothesis except that of systematic catalogue error; it was found that the observations could be reconciled by supposing that the wire was set always to the left of the star by somewhat over a second of arc.

During the summer of 1908 it was decided to make some special observations to test, qualitatively at least, the validity of this hypothesis. In order to obtain as many independent tests as possible, several methods of observation were devised. The most obvious of all, the observation of transits of zenith stars facing alternately north and south, was impracticable with the telescope used, since the standards interfered with the proper manipulation of the micrometer wheels. The first method used was the

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measurement of zenith distances; as the telescope was fitted with an erecting diagonal eye-piece, this was comparatively simple. After setting on a star at some distance from the zenith, preferably a slow-moving north star (the micrometer head having been previously turned so that the moveable wire was horizontal), the diagonal eye-piece was turned in either direction about 45° from the vertical plane; on looking into it with the line joining the eyes horizontal, the micrometer wire appeared vertical, the direction of increasing zenith distance being towards the right or left according to the direction in which the eye-piece had been turned. By making a number of settings with eye-piece alternately right and left the error of bisection was readily found. In this method the question is not complicated by the motion of the star, which appears to move *along* the wire, the motion in any case being very slow if high polars be chosen; thus the result is practically the simple error of bisection for a stationary object. By combining the results from different stars the variation depending on magnitude may also be found. The stars principally used were Polaris and λ Ursæ Minoris; with the latter as many as a hundred settings could easily be made at one culmination. Several other stars of high declination were also used, the total number of bisections made being about 400. Observations of a similar kind on Polaris and λ Ursæ Minoris were also made by C. C. Smith.

The other methods used, which were three in number, all depended on the observation of transits. They were as follows:—

I. Observations of the same star (over different parts of the field) were made with the ordinary diagonal eye-piece (erecting), and also with a simple eye-piece of about the same magnifying power; as the apparent direction of motion is altered by interchanging the eye-pieces, the difference in times of transit (reduced to the meridian) was taken to be double the error of bisection. In this case the observations are not made under exactly similar conditions; with the direct eye-piece a movement of the hand-wheels appears, to an observer accustomed to the erecting eye-piece, to move the wire in the wrong direction, and there is no assurance *a priori* that this will not alter the 'lag' effect, if this exists. The definition is also somewhat better with the direct eye-piece, which might tend to diminish the error of bisection in that case; the result might also be affected by the difference in the observer's position. On account of the use of the direct eye-piece, observations were not possible within 35° of the zenith; stars were observed near the equator and near the pole, both above and below. When reduced to equatorial interval it was found that the error of bisection was practically the same for polar and equatorial stars, the difference in times of transit being, as was expected, of opposite sign for north stars at upper culmination. Care was taken to have the magnitudes varied enough to determine the magnitude equation. The whole number of stars observed was 45.

II. Observations of a few equatorial stars were made in the ordinary way, and also with the diagonal eye-piece turned through 180° , so that the observer faced upwards at an angle in looking into it. As before, the error of bisection was taken to be one-half the difference in the reduced times of transit. Theoretically this method is free from objection, as the conditions of observation are the same in both cases; practically, however, the difficulty of observing with the eye-piece down, without a suitable reclining chair, was found to be a very serious objection; only twelve stars were observed.

III. As in the case of the zenith distance observations above, the star was observed with eye-piece both left and right, and also (over another part of the field) in the ordinary way. With eye-piece left the apparent motion of the star was upward, the wire appearing horizontal; with eye-piece right the motion was downward; the mean of these two observations was taken to be free from error of bisection; hence the error for the ordinary observation was derived. The number of stars observed was 43.

In the several methods described above the results are independent of catalogue places, and include both the absolute value of the error of bisection and its variation with magnitude. Computations were also made from the residuals of the southern Berliner Jahrbuch stars occurring in the ordinary observations to determine the magnitude equation in the case of both S and CS ; this involves the assumption that the B. J. places are free from magnitude equation, which is probably very nearly the case. The residual of each B. J. star in a set was diminished by the mean of all; the same was done with the magnitudes; there results for each star an observation equation of the form $b m = v$, m being the magnitude of the star diminished by the mean magnitude for the set, v the residual diminished in the same way, and b the unknown magnitude equation; the reduction to this form enables stars from different sets to be combined indifferently to obtain the value of b . 170 stars were used in deducing the magnitude equation of S , 143 for that of CS .

From the observations by S and CS in October and November, on the nights on which the two observers worked simultaneously with the same instrument, a computation was made of their difference of personal equation and its variation with magnitude, on the supposition that it was wholly due to bisection error. This supposition appeared extremely probable from the fact that of 19 north stars (at upper culmination) and 43 south stars, every one of the north stars gave a negative difference in the sense $S - CS$, and every one of the south stars a positive difference. The signs of the differences for the north stars having been changed, each star furnished an observation equation of the form $a + b m = v \cos \delta$ for the determination of difference of bisection error, a and b being the quantities to be determined, m the magnitude, and v the observed difference. The 62 equations were combined by least squares, and a and b evaluated.

The results of all the observations and computations described above are collected in Table V. In the case of the zenith distances the bisection errors, for the sake of uniformity, have been reduced to their equivalents in time; all the results are expressed in equatorial interval; the bisection error has throughout been considered positive when the wire is set to the apparent left of the star. The inter-agreement of the means is no doubt much closer than might have been expected from the varied nature of the observations and their comparatively limited number. The results, however, point very strongly to the reality of a large bisection error for the observer S , and to its variation with magnitude; the agreement for the two observers points to the probability that their personal equations arise almost wholly from this cause. For a set observed at the latitude of Ottawa ($45^{\circ} 24'$), composed of north stars of magnitude 5.5 at declination 77° and south stars of magnitude 4 at declination 25° , which is about the average composition, the personal equation between S and CS due to error of bisection, assuming the latter to be $-.074$ sec. $- .0129 (m - 4)$, would be $-.036$ sec.; the actual value as obtained directly above was $-.034$ sec. The closeness of this agreement is, however, no doubt partly attributable to chance.

The observations of N in October, on the three nights when he worked simultaneously with S , appear to follow a similar law, the differences being all negative for the north stars, and nearly all positive for the south stars; for his observations in November and December, however, after the second change in his personal equation, this is not the case. The observations were considered too few to make a definite analysis; his magnitude equation during the early part of the summer, as deduced from the residuals, was $-.0019$ sec. per magnitude, a practically evanescent quantity.

It may be remarked that transits of stars near the zenith, observed with a broken type telescope, will be free from error of bisection when the telescope is reversed during the observation of each star. For an ordinary telescope the condition of elimination, so far as effect on the deduced clock-error is concerned, is that the sines of the mean zenith distances of south and of north stars should be proportional to the errors of bisection corresponding to their respective mean magnitudes, provided that the

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zenith distances and magnitudes of individual stars do not differ widely from these means. As, however, the fulfilment of this condition, even approximately, would be extremely difficult in actual practice, and as the resulting error varies fairly rapidly with changes in the conditions, the only practical remedy would appear to be the measurement by each observer of his bisection error and the correction of each separate observation for it if large. Observations of both Polaris and λ Ursæ Minoris at a single culmination, by the method outlined above, would be sufficient to determine whether the error and its variation with magnitude were sufficiently large to be taken into account; if so, further observations of the same kind could be made if desired.

In the measurement of azimuth by the transits of close circumpolars, the clock error being supposed known, the error of bisection enters for more than its full value into the deduced azimuth. In this case the error might either be measured directly as above, and a correction applied, or it might be eliminated by observing with eyepiece alternately left and right as described under III. above.

TABLE II.—PERSONAL EQUATIONS OF HOME OBSERVERS.

| Period, 1908. | CS-S | N-S | |
|---------------------------|------------------|-----------------|--------------|
| | s | s | |
| June 1-20 | -.011 \pm .021 | .098 \pm .016 | Preliminary. |
| June 21-July 15 | .025 \pm .014 | .099 \pm .015 | |
| Aug. 2-31 | .046 \pm .014 | .057 \pm .015 | |
| Sept. 3-29 | .056 \pm .018 | .077 \pm .019 | |
| Oct. 1-7 | .050 \pm .016 | .061 \pm .022 | |
| May 14-July 15 | .034 \pm .007 | .113 \pm .009 | Adopted. |
| July 16-Oct. 15 | | .048 \pm .009 | |

TABLE III.—PERSONAL EQUATION OF F. A. McDIARMID.

| Date. | Time. | CLOCK CORRECTIONS. | | | | PERSONAL EQUATION OF M. | | |
|-------------------------|-------|--------------------|-------|-------|-------|-------------------------|-------|-------|
| | | M | S* | N† | CS | S-M | N-M | CS-M |
| 1908. | h. m. | s | s | s | s | s | s | s |
| Sept. 14 | 19 00 | 9.444 | | | 9.453 | | | .009 |
| | 20 25 | 9.424 | | | 9.519 | | | .095 |
| " 16 | 19 10 | 9.505 | | | 9.561 | | | .046 |
| | 20 20 | 9.493 | | | 9.499 | | | .006 |
| " 19 | 19 10 | 9.619 | | 9.602 | | | .043 | |
| | 20 10 | 9.562 | | 9.699 | | | .137 | |
| " 20 | 19 20 | 9.565 | 9.650 | | | .085 | | |
| | 20 35 | 9.540 | 9.604 | | | .064 | | |
| " 21 | 20 05 | 9.656 | 9.650 | | | -.006 | | |
| " 25 | 20 45 | 9.684 | | | 9.706 | | | .022 |
| " 29 | 19 50 | 9.812 | 9.847 | | | .035 | | |
| | 21 15 | 9.844 | 9.816 | | | -.028 | | |
| Oct. 1 | 20 05 | 9.918 | | | 9.906 | | | -.012 |
| " 14 | 22 00 | 0.522 | 0.490 | 0.430 | | -.032 | -.092 | |
| Means | | | | | | .020 | .029 | .028 |
| Weighted mean | | | | | | | 0.025 | |

*With personal equation +.034 sec. applied.

†With personal equation -.014 " " "

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TABLE IV.—PERSONAL EQUATION OF W. C. JAKES.

| Date | Time. | CLOCK CORRECTIONS. | | | | PERSONAL EQUATION OF J. | | |
|--|-------|--------------------|-------|-------|-------|-------------------------|-------|-------|
| | | J. | S* | N† | C S | S—J | N—J | CS—J |
| 1908. | h m | s | s | s | s | s | s | s |
| Nov. 21..... | 0 55 | 2·319 | 2·323 | 2·246 | ..... | ·006 | ·073 | ..... |
| " 26..... | 23 50 | 2·988 | ..... | 2·938 | 2·988 | ..... | ·050 | ·000 |
| " 29..... | 0 30 | 3·239 | 3·287 | ..... | 3·307 | ·028 | ..... | ·048 |
| | 2 20 | 3·210 | 3·293 | ..... | 3·309 | ·083 | ..... | ·099 |
| Dec. 2..... | 0 20 | 3·516 | ..... | ..... | 3·664 | ..... | ..... | ·148 |
| | 1 50 | 3·596 | ..... | 3·502 | 3·611 | ..... | ·084 | ·025 |
| " 5..... | 23 05 | 3·947 | 4·015 | 3·850 | ..... | ·068 | ·097 | ..... |
| | 0 55 | 3·920 | 4·028 | 3·813 | ..... | ·108 | ·107 | ..... |
| Means..... | | | | | | ·059 | ·082 | ·064 |
| Weighted mean from observations of S and C S, 0·061 sec. | | | | | | | | |

* With personal equation + ·034 sec. applied.

† With personal equation - ·014 sec. applied.

TABLE V.—ERRORS OF BISECTION.

| Method. | Observer. | Bisection Error. | |
|-------------------------|-----------|------------------|---------------|
| | | S | S |
| Zenith Distance..... | S | ·074 | ·0119 (m—4) |
| Transits I..... | S | ·101 | ·0091 (m—4) |
| " II..... | S | ·065 | ·0083 (m—4) |
| " III..... | S | ·151 | ·0252 (m—4) |
| Residuals..... | S | ..... | ·0118 (m—4) |
| Zenith Distance..... | C S | ·083 | + ·0000 (m—4) |
| Residuals..... | C S | ..... | ·0038 (m—4) |
| Direct Differences..... | S—C S | ·074 | ·0129 (m—4) |
| Means. | S | ·098 | ·0134 (m—4) |
| | C S | ·033 | ·0019 (m—4) |
| | S—C S | ·074 | ·0129 (m—4) |

TIME SERVICE.

The ordinary work in connection with the Time Service has consisted, as in the past, of the necessary attention to the up-town service, the sending out of time-signals to the telegraph company, dropping of the time-ball on Parliament Hill, supplying of mean and sidereal time by telephone to those requiring it, occasional rating of chronometers, testing of aneroid barometers, &c., together with the maintenance of the clocks and apparatus at the Observatory.

In addition to the daily time-signals to the telegraph company, the beats of the mean-time clock were on one occasion sent to a member of the Geological Survey staff at Blackwater, B.C., several hundred miles north of the main line of the Canadian Pacific Railway. On this occasion the transcontinental copper wire of the Canadian Pacific Telegraph was used as far as Vancouver; the signals were received at Blackwater satisfactorily.

During the winter season, unless required for special purposes, observations for time were taken usually not oftener than once a week, and occasionally at slightly

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longer intervals. When required only for ordinary time-keeping purposes (the clock error not being required more accurately than to within one or two-tenths of a second) this is found amply sufficient with our Riesler Standard Clock.

Some trouble has been experienced with the maintenance of a perfectly uniform pressure within the case of the Sidereal Standard. During May, 1908, a leak at the rate of several millimetres per month developed; by careful resealing this was reduced, though not entirely eliminated; throughout the whole summer and the ensuing winter a practically uniform leak of one millimetre per month persisted; as, however, the leak was uniform, it did not interfere seriously with the performance of the clock; no attempt was made to keep the pressure at its original value by periodical exhaustion, as it was considered that this would interfere with the continuity of rate. In March, 1909, the electric seconds-contact failed; the necessity of dismounting the clock was taken advantage of to have it cleaned and oiled, after which it was again mounted and exhausted to a pressure of 688 millimetres. An analysis of its rate from June to October, 1908, is given in Appendix A below.

Reference was made in my last report to the proposed extension of the Time Service to the Printing Bureau, the Mint and the Archives Building. It was, however, later decided by the Public Works Department not to equip the Printing Bureau at present. A switch-room to contain the apparatus for serving the two remaining buildings was obtained in the Mint, and was fitted up under my supervision by the electricians of the Public Works Department; this work was completed on September 18. The master-clock for operating the dials was the one which had been formerly used in the basement of the Supreme Court Building as primary for the experimental system installed in 1902. For use as a secondary master-clock it required to be fitted with a minute-contact and a synchronization magnet, as well as with the cut-out described in my last report. This was done in the Observatory workshop, and the clock was set up in the switch-room at the Mint for regulation of rate on August 11. On September 19 at noon the dials in the Mint and Archives Building were started; the master-clock was not put under direct control from the Observatory until some little time later.

In the other departmental buildings there have, as usual, been changes and some additions to the dials in operation. The necessary attention to the system has in the main, as heretofore, devolved upon Mr. Robertson; Mr. Nugent has also frequently assisted in this work. Below is a list of the number of clocks in operation in the city and at the Observatory:—

| | Mar. 31, '09. | Mar. 31, '08. |
|--|---------------|---------------|
| Minute dials—Parliament Building | 49 | 46 |
| East Block | 36 | 35 |
| West Block | 63 | 61 |
| Langevin Block | 48 | 48 |
| Post Office | 20 | 20 |
| Thistle Block | 2 | 2 |
| Ottawa Electric Co. | 1 | 1 |
| Mint | 16 | .. |
| Archives | 7 | .. |
| Observatory | 28 | 28 |
| Tower clocks | 2 | 2 |
| Program clock | 1 | 1 |
| Seconds dials | 3 | 2 |
| Total electrically driven clocks | 276 | 246 |

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| | Mar. 31, '09. | Mar. 31, '08. |
|----------------------------------|---------------|---------------|
| Secondary Master-clocks. | 8 | 7 |
| Primary clocks. | 4 | 4 |
| | <hr/> | <hr/> |
| Total. | 288 | 257 |
| | <hr/> | <hr/> |

I have the honour to be, sir,

Your obedient servant,

R. M. STEWART.

APPENDIX A.

RATE OF THE STANDARD CLOCK OF THE DOMINION OBSERVATORY.

R. M. STEWART.

The construction of astronomical clocks has arrived at such a degree of perfection that, for the present at least, it is probably useless to look for much improvement in this direction. Attention requires to be directed more especially to the conditions under which the clock operates, with a view to keeping these as constant as possible. There are three main factors which influence the performance of a clock: (1) rigidity of mounting and freedom from vibration; (2) compensation for or elimination of variations in atmospheric pressure; (3) compensation for temperature.

The Sidereal Standard of the Dominion Observatory (Riefler No. 75) is of Riefler's well known primary type. The whole clock is enclosed in an air-tight glass cylinder to eliminate all changes of air pressure; it may be remarked here that the rate-variation due to barometer, if not eliminated, is very considerable, amounting in the present case to nearly half a second per day per inch change of barometer. The pendulum rod is of the particular composition of nickel-steel known as invar, whose temperature coefficient of expansion is very small. The temperature compensation is effected by a short compound cylinder of brass and steel, upon which the pendulum-bob is supported. The escapement is of Riefler's own type, one of the principal characteristics being that the impulse to the pendulum is given through the suspension spring; it combines many of the advantages of the two best fundamental types, the 'free' and 'gravity' escapements. The winding is electrical, and is operated automatically at intervals of 20 to 30 seconds.

Though the temperature-compensation of a good pendulum is sufficiently accurate for all ordinary purposes, the refinements of astronomical observations make it necessary in addition to keep the temperature to which it is subjected as constant as practicable. It is considered by many authorities that a variation of a degree or two is not attended by any appreciable effects, but in our case the principle has been followed of aiming at a fairly high degree of refinement in temperature control. The temperature of the clock-room as a whole is kept nearly constant by means of a thermostat controlling an electric heater, while a fan keeps the air in constant circulation throughout the room. This, however, was not found to give the refinement desired, and a separate case was built around the clock. The temperature within the case is main-

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tained slightly above that of the room by a Callender Electric Recorder, which controls a small electric heater, the air being kept in circulation as above by a small fan; the maximum variation is of the order of a tenth of a degree centigrade.

A good test of the rate of the clock is given by the longitude operations of the summer of 1908. Observations for clock error were made on every clear night for four and a half months, from the beginning of June* up to the middle of October; in general at least two independent determinations were made on each night; the total number of nights was 91; three observers took part in the work, two of them observing usually on alternate nights, and the third less frequently.

Owing to the continuity of the work and the accurate running of the clock, it was found possible to compute the relative personal equations of the observers from the regular observations. To do this, the season was broken up into convenient periods, averaging about a month in length, and a rigorous least square computation of the relative personal equations obtained for each; these separate values were combined with the results of some special observations for personal equation, and final values adopted. The application of these quantities to the observations gave clock errors presumably free from relative personal equation. The general rate showed great uniformity throughout the season, with the exception of the latter part of July; as the rate in this period was so evidently anomalous, it has been left out of consideration in what follows.

In computing clock-rates the effect of errors of observations must not be neglected; where the observations from which the rate is computed are separated by only a short interval, the apparent effect of such errors may be considerable; this, however, decreases as the interval is increased. For this reason the rates in Table I. have been computed, as shown, for intervals of five days, so far as the observations would permit. The second column shows the observed daily rate in seconds for each period, the third the difference between each of these observed rates and their mean, the average difference being $\pm .015$ sec. per day. Assuming a constant change of rate with the time and solving by least squares the rate-formula obtained is $+.0500 - .00023 (T - \text{Aug. 8})$; the rates computed from this formula are given in the fourth column, while the fifth gives the differences between these and the observed rates, the average deviation being $\pm .013$ sec.

For the sake of comparison with another clock of the same kind, and to show the effect of temperature-control, Table II. gives a similar analysis of the rate of the United States Naval Observatory clock (Riefler No. 70) for a period of three months in 1904, as published by Prof. Eichelberger†; in this case one period of ten days is omitted; the average interval between observations is 4.2 days. As the variation of temperature during this test was considerable, a temperature-term is introduced in the computed rate. It will be observed that the mean deviation from computed rate is almost the same for both clocks; this may be taken to mean that the ideal performance (that is, the best performance of which the clock is capable) is practically the same in both cases; this is of course to be expected from two clocks of the same type and manufacture. So far as actual performance goes, however, they are to be judged by the residuals from mean, and not computed, rate, and here the Ottawa clock has a very decided advantage, its actual performance being reasonably close to the ideal one. The reason is not far to seek; it lies in the absence of temperature-variations and their disturbing effects. It would not be fair to close this comparison without stating that the United States Naval Observatory has now a new clock room, where, I believe, greater attention is paid to temperature control.

As mentioned above, the interval between observations for clock error will influ-

* The observations made in May were not considered in this paper because the rate was affected by several changes of pressure and a certain amount of direct disturbance due to adjustments and re-sealing.

† Science, 1907, p. 451.

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ence the accuracy of the deduced rate, owing to the effect of errors of observation. In general, the residual rate V (observed minus computed) will consist of three parts:— (1) the actual variation of clock rate v_1 , (2) an apparent part v_2 depending on errors of observation and interval, (3) another apparent part v_3 due to error in the personal equation employed (if the observations have been made by different observers). Hence

$$V = v_1 + v_2 + v_3$$

and, as may easily be shown, if the number of intervals considered be large,

$$[V^2] = [v_1^2] + [v_2^2] + [v_3^2];$$

or denoting the corresponding probable errors by R , r_1 , r_2 and r_3 ,

$$R^2 = r_1^2 + r_2^2 + r_3^2.$$

Now if r denote the probable error of a single determination of clock-error, and if, on two nights separated by an interval of N days, there be made respectively n_1 and n_2 determinations of clock error, we shall have for that particular interval

$$r_2^2 = \frac{1}{n_1} + \frac{1}{n_2} \cdot r^2.$$

The value of r for the observations considered, obtained by an independent method, is .020 sec. Substituting this value and deducing that of r_2^2 for each of the intervals in Table I., and taking the mean, the result is

$$r_2^2 = (.0046)^2.$$

Again, if r^1 denote the probable error of the value of personal equation employed, we have

$$r_2 = \frac{1}{N} \cdot r^1;$$

the value of r^1 is .008 sec.

Also, the value of R obtained from the residuals in Table I. is .012; hence $r_1 = \sqrt{R^2 - r_2^2 - r_3^2} = \pm .011$ sec.; this is the probable value of the actual accidental change in (daily) rate from one period of five days to the next.

Proceeding in exactly the same way, but using, instead of five-day intervals, all the observations available, the average interval being 1.47 days, the values of the quantities are as follows:—

$$R = .025 \text{ sec.}$$

$$r_2 = .0183 \text{ sec.}$$

$$r_3 = .0054 \text{ sec.}$$

$$\text{and hence } r_1 = .016 \text{ sec.}$$

Hence it appears that a clock is liable to small irregular fluctuations of rate from day to day, it being in the present case an even chance that such fluctuations shall lie within the limits $\pm .016$ sec.; when, however, the interval is increased, the fluctuations tend to counterbalance one another.

It would appear also that the clock is liable in addition to anomalous changes of rate for longer or shorter periods; from July 16 to July 31 the average rate was $-.022$ sec., as against $-.050$ sec. for the remainder of the summer. It has been suggested that this is a peculiarity of invar pendulums, due to some not well understood irregularities in the interval constitution of the material; similar effects have been noticed in other Riefler clocks, but the question can hardly be considered definitely settled as yet. Such changes in rate are, however, for astronomical purposes, less objectionable than the irregular ones (here eliminated) due to irregular variations in temperature and pressure.

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TABLE I.—DOMINION OBSERVATORY CLOCK.

| Date. | Daily Rate. | O - M | Computed Rate. | O - C |
|----------------|-------------|--------|----------------|--------|
| 1908. | s. | s. | s. | s. |
| June 1-6 | ·059 | ·009 | ·065 | - ·006 |
| " 6-11 | ·061 | ·011 | ·064 | - ·003 |
| " 11-17 | ·037 | - ·013 | ·063 | ·026 |
| " 17-21 | ·069 | ·019 | ·062 | ·007 |
| " 21-26 | ·072 | ·022 | ·060 | ·012 |
| " 26-31 | ·088 | ·038 | ·059 | ·029 |
| July 1-6 | ·049 | - ·001 | ·058 | - ·009 |
| " 6-11 | ·055 | ·005 | ·057 | - ·002 |
| " 11-16 | ·046 | - ·004 | ·056 | - ·010 |
| Aug. 0-5 | ·083 | ·033 | ·051 | ·032 |
| " 5-9 | ·072 | ·022 | ·050 | ·022 |
| " 9-15 | ·054 | ·004 | ·049 | ·005 |
| " 15-20 | ·049 | - ·001 | ·048 | ·001 |
| " 20-25 | ·042 | - ·008 | ·047 | - ·005 |
| " 25-30 | ·012 | - ·038 | ·046 | - ·034 |
| " 30-35 | ·043 | - ·007 | ·044 | - ·001 |
| Sep. 4-8 | ·034 | - ·016 | ·043 | - ·009 |
| " 8-14 | ·049 | - ·001 | ·042 | ·007 |
| " 14-19 | ·039 | - ·011 | ·041 | - ·002 |
| " 19-25 | ·004 | - ·046 | ·040 | - ·036 |
| " 25-31 | ·033 | - ·017 | ·038 | - ·005 |
| Oct. 1-6 | ·033 | - ·017 | ·037 | - ·004 |
| " 6-11 | ·048 | - ·002 | ·036 | ·012 |
| " 11-15 | ·061 | ·011 | ·035 | ·026 |
| Mean. | ·050 | ± ·015 | | ± ·013 |
| Range. | | ·084 | | ·068 |

s.
 Computed rate = ·0500 - ·00023 (T - Aug. 8).

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TABLE II.—U. S. NAVAL OBSERVATORY CLOCK.

| Date. | Daily Rate. | Mean Temp. | O - M | Computed Rate. | O - C |
|--------------------|-------------|------------|--------|----------------|--------|
| 1904. | s. | C. | s. | s. | s. |
| Feb. 8-11. | .019 | 28.3° | .003 | .009 | .010 |
| " 11-15. | .014 | 28.5 | .030 | .006 | .008 |
| " 15-20. | .005 | 28.3 | .011 | .002 | .007 |
| Mar. 1-4. | .026 | 28.2 | .042 | .012 | .014 |
| " 4-9. | .010 | 28.2 | .026 | .016 | .006 |
| " 9-16. | .022 | 28.1 | .038 | .018 | .004 |
| " 16-18. | .043 | 28.1 | .059 | .022 | .021 |
| " 18-22. | .022 | 28.0 | .038 | .021 | .001 |
| " 22-25. | .029 | 28.0 | .045 | .024 | .005 |
| " 25-28. | .002 | 27.7 | .014 | .014 | .016 |
| " 28-34. | .007 | 27.7 | .023 | .018 | .011 |
| Apl. 3-5. | .017 | 27.4 | .001 | .009 | .026 |
| " 5-13. | .002 | 26.9 | .014 | .014 | .012 |
| " 13-16. | .026 | 26.5 | .010 | .021 | .005 |
| " 16-19. | .034 | 26.3 | .018 | .027 | .007 |
| " 19-22. | .002 | 26.4 | .014 | .020 | .018 |
| " 22-31. | .029 | 25.0 | .013 | .077 | .048 |
| May 1-4. | .113 | 24.3 | .067 | .103 | .010 |
| " 4-7. | .082 | 24.1 | .066 | .109 | .027 |
| " 7-12. | .161 | 24.0 | .145 | .109 | .052 |
| Mean. | .016 | | ± .035 | | ± .015 |
| Range. | | | .204 | | .100 |

Computed rate = $\frac{.0161}{.00103} (T - \text{Mar. 29}) - .0456 (t - 27^{\circ} \text{C})$.

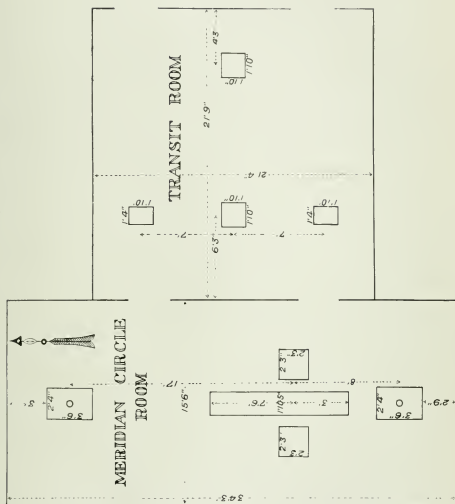


FIG. 1—Floor Plan of Transit Annex.

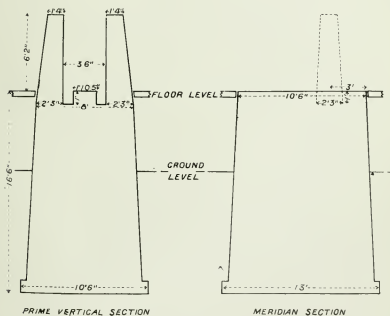
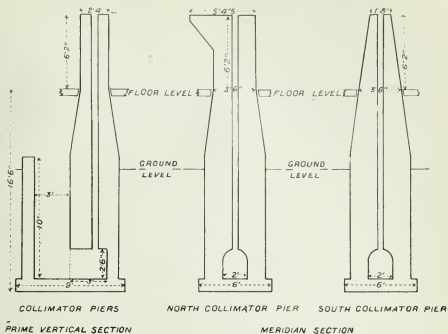


FIG. 2—Piers in Meridian Circle Room.

STEWART-MERIDIAN WORK AND TIME SERVICE.

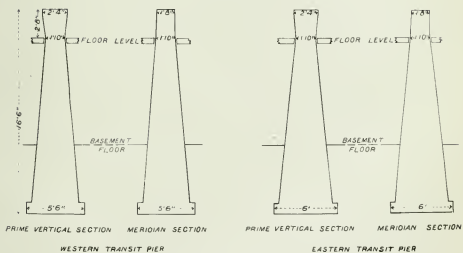
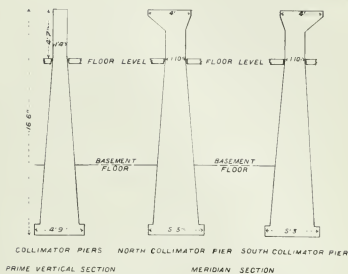


FIG. 3—Piers in Transit Room.

APPENDIX 4.

REPORT OF THE CHIEF ASTRONOMER, 1909.

**TABULAR STATEMENT OF LONGITUDE
AND LATITUDE OBSERVATIONS.**

BY

J. MACARA.

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MAP.

Map showing position of Astronomical Stations established.

APPENDIX 4.

TABULAR STATEMENT OF LONGITUDE AND LATITUDE
OBSERVATIONS.

DOMINION ASTRONOMICAL OBSERVATORY,
DEPARTMENT OF THE INTERIOR,
OTTAWA, CANADA, March 31, 1909.

W. F. KING, Esq., LL.D., C.M.G.,
Chief Astronomer,
Ottawa.

SIR,—I have the honour to transmit herewith a tabular statement of the differences of longitude and the latitude results of stations observed in 1908. Annexed thereto is also a description of the stations occupied. A synopsis of the statement giving the longitude and latitude of the various stations will be found on page 619.

The accompanying map shows the position of the various astronomical stations established up to the date of this report.

I have the honour to be, sir,
Your obedient servant,

J. MACARA.

DIFFERENCE OF LONGITUDE BETWEEN GATEWAY, B. C. AND SEATTLE.

| Date. | DIFFERENCE OF CHRONO-GRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | | | Time of Trans- mission. | |
|---------------|-----------------------------|-----------|------------------|----|-------------------|---------|------------------|----|--------------------------|-----------|------------------|----|-----------|-----------|-------------------------|----|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | Mean. | | | r. |
| | ml. | s. | ml. | s. | s. | s. | ml. | s. | ml. | s. | ml. | s. | ml. | s. | | |
| 1908. | | | | | | | | | | | | | | | | |
| April 27..... | 28 51.293 | 28 51.122 | | | 1 7.29 | 13 7.15 | | | 28 39.307 | 28 39.136 | | | 28 39.292 | 28 39.065 | | |
| " 28..... | 28 50.297 | 28 50.210 | | | 1 9.32 | 13 0.73 | | | 28 39.256 | 28 39.069 | | | 28 39.163 | 28 39.036 | | |
| " 29..... | 28 49.112 | 28 48.924 | | | 2 8.59 | 12 0.98 | | | 28 39.313 | 28 39.125 | | | 28 39.219 | 28 39.029 | | |
| " 30..... | 28 48.358 | 28 48.149 | | | 7 0.78 | 13 1.42 | | | 28 39.294 | 28 39.085 | | | 28 39.190 | 28 39.009 | | |

h. m. s.
 28 39 199
 28 39 274
 28 39 274
 28 39 274

Observers: { West—W. C. JACQUES.
 { East—F. A. McDIARMID.

d A.....
 A Seattle.....
 A Gateway.....

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DIFFERENCE OF LONGITUDE BETWEEN BOUNDARY (WANETA) B.C. AND SEATTLE.

| Date. | DIFFERENCE OF CHRONO- GRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | | | Time of Trans- mission. | |
|---|---------------------------------|--------|---------------------|--------|---------------------|----|---------------------|----|--------------------------|--------|---------------------|--------|-------|--------|----------------------------------|-------|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | Mean. | | | t_c |
| | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | | |
| 1908. | | | | | | | | | | | | | | | | |
| May 13 | 20 | 11 550 | 20 | 11 400 | -12 552 | | -1 34 781 | | 18 | 49 321 | 18 | 49 171 | 18 | 49 246 | -043 | 075 |
| " 16 | 20 | 14 371 | 20 | 14 126 | -12 815 | | -1 37 742 | | 18 | 49 344 | 18 | 49 199 | 18 | 49 271 | -018 | 072 |
| " 22 | 20 | 19 838 | 20 | 19 671 | -13 851 | | -1 44 258 | | 18 | 49 431 | 18 | 49 265 | 18 | 49 347 | 058 | 082 |
| " 25 | 20 | 22 901 | 20 | 22 747 | -15 025 | | -1 48 534 | | 18 | 49 292 | 18 | 49 258 | 18 | 49 315 | 026 | 077 |
| " 26 | 20 | 23 732 | 20 | 23 565 | -15 338 | | -1 49 722 | | 18 | 49 348 | 18 | 49 191 | 18 | 49 265 | -024 | 074 |
| <div>Observers West—W. C. JAGUES. East—F. A. McDRUMMID.</div> | | | | | | | | | | | | | | | | |
| <div>$d\lambda$..... h. m. s. 18 49 289 λ Seattle..... 8 09 20 274 λ Boundary..... 30 30 985</div> | | | | | | | | | | | | | | | | |

h. m. s.
d A. 18 49 280
A Seattle ... 20 274
A Boundary ... 7 50 985

Observers { West—W. C. JACQUES.
 { East—F. A. McDIARMID.

DIFFERENCE OF LONGITUDE BETWEEN ST. JOHN, N.B., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO-GRAPH. | | | | Clock Correction. | | | | DIFFERENCE OF LONGITUDE. | | | | | | Time of Trans- mission. |
|--------|-----------------------------|----|------------------|----|-------------------|----|------------------|----|--------------------------|----|------------------|--|-----------|--|----------------------------|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | | | |
| | | | | | | | | | | | Mean. | | E. | | |
| | | | | | | | | | | | | | | | |
| m. | s. | m. | s. | R. | R. | m. | s. | m. | s. | R. | R. | | | | |
| 1908. | | | | | | | | | | | | | | | |
| May 13 | 38 51 225 | | 38 51 124 | | + 2 277 | | 13 112 | | 38 35 836 | | 38 35 735 | | 38 35 785 | | .050 |
| " 14 | 38 52 205 | | 38 52 202 | | + 2 377 | | 14 092 | | 38 35 836 | | 38 35 733 | | 38 35 785 | | .052 |
| " 15 | 38 54 290 | | 38 54 213 | | + 2 477 | | 16 005 | | 38 35 817 | | 38 35 731 | | 38 35 774 | | .043 |
| " 16 | 38 55 284 | | 38 55 193 | | + 2 577 | | 16 911 | | 38 35 796 | | 38 35 705 | | 38 35 751 | | .046 |
| " 18 | 38 57 052 | | 38 56 950 | | + 2 777 | | 18 404 | | 38 35 871 | | 38 35 778 | | 38 35 825 | | .047 |

Observers: (West—D. B. NUGENT, C. C. SMITH,
(East—C. A. FRENCH.

$d\lambda$ h. m. s.
 EA Ottawa..... 5 02 51.797
 EA St. John..... 4 24 16.013

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN SPRAGUE, MAN., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO-GRAPH. | | | | | | CLOCK CORRECTION. | | | | | | DIFFERENCE OF LONGITUDE. | | | | | | Time of Transmission | | |
|--------|-----------------------------|----|--------|------------------|----|--------|-------------------|--------|------------------|----|------------------|--------|--------------------------|------------------|--------|----|-------|--------|----------------------|-----|----|
| | Western Signals. | | | Eastern Signals. | | | Western Station. | | Eastern Station. | | Western Signals. | | | Eastern Signals. | | | Mean. | | | s. | |
| | h. | m. | s. | h. | m. | s. | m. | s. | h. | m. | s. | h. | m. | s. | h. | m. | s. | h. | | | m. | s. |
| 1906. | | | | | | | | | | | | | | | | | | | | | |
| June 5 | 1 | 12 | 30.467 | 1 | 12 | 30.201 | 7 | 05.961 | +5.255 | 1 | 19 | 41.683 | 1 | 19 | 41.417 | 1 | 19 | 41.550 | 019 | 133 | |
| " 7 | 1 | 12 | 25.618 | 1 | 12 | 25.357 | 7 | 10.843 | +5.290 | 1 | 19 | 41.751 | 1 | 19 | 41.470 | 1 | 19 | 41.610 | 041 | 140 | |
| " 9 | 1 | 12 | 24.968 | 1 | 12 | 24.712 | 7 | 11.211 | +5.457 | 1 | 19 | 41.669 | 1 | 19 | 41.383 | 1 | 19 | 41.526 | 043 | 143 | |
| " 11 | 1 | 12 | 23.721 | 1 | 12 | 23.436 | 7 | 12.375 | +5.560 | 1 | 19 | 41.656 | 1 | 19 | 41.371 | 1 | 19 | 41.514 | 055 | 143 | |
| " 12 | 1 | 12 | 21.451 | 1 | 12 | 21.127 | 7 | 14.767 | +5.588 | 1 | 19 | 41.806 | 1 | 19 | 41.482 | 1 | 19 | 41.644 | 075 | 162 | |

Observers: (West—F. A. McDIARMID.

(East—C. C. SMITH, D. R. NUGENT, R. M. STEWART.

d^N h. m. s.
 N Ottawa 1 19 41.569
 N Sprague 5 02 51.797
 N Sprague 6 22 33.366

DIFFERENCE OF LONGITUDE BETWEEN RAINY RIVER, ONT., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONOGRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | | | Time of Trans- mission. | | | |
|----------|-------------------------------|----|---------------------|----|---------------------|--------|---------------------|--------|--------------------------|----|--------|---------------------|----|--------|----------------------------------|-------|--------|------|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | | Eastern Signals. | | | | Mean. | s | |
| | h. | m. | s. | h. | m. | s. | h. | m. | s. | h. | m. | s. | h. | m. | | | | s. |
| 1908. | | | | | | | | | | | | | | | | | | |
| June 16. | 1 | 14 | 42.762 | 1 | 14 | 42.490 | -35.753 | +5.743 | 1 | 15 | 24.258 | 1 | 15 | 23.986 | 1 | 15 | 24.122 | -050 |
| " 19. | 1 | 14 | 36.517 | 1 | 14 | 36.292 | -41.892 | +5.826 | 1 | 15 | 24.206 | 1 | 15 | 23.951 | 1 | 15 | 24.079 | -007 |
| " 20. | 1 | 14 | 34.509 | 1 | 14 | 34.327 | -43.061 | +5.875 | 1 | 15 | 24.135 | 1 | 15 | 23.863 | 1 | 15 | 23.999 | -073 |
| " 23. | 1 | 14 | 27.302 | 1 | 14 | 27.004 | -50.737 | +6.290 | 1 | 15 | 24.257 | 1 | 15 | 23.989 | 1 | 15 | 24.088 | -016 |

OBSERVERS { West.—F. A. McDIARMID.
 { East.—R. M. STEWART, D. B. NGENT, C. C. SMITH.

$d\lambda$ h. m. s.
 λ Ottawa 1 15 24.072
 λ Rainy River 5 02 51.797
 λ Rainy River 6 18 15.869

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN MONCTON, N.B., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONOGRAPH. | | CLOCK CORRECTION | | DIFFERENCE OF LONGITUDE. | | | Time of Trans- mission. | | | |
|---------|----------------------------|--------|------------------|--------|--------------------------|--------|------------------|-------------------------|----|--------|-----|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | | | |
| | m. | s. | m. | s. | m. | s. | m. | | s. | | |
| 1906. | | | | | | | | | | | |
| May 21 | 43 | 12 893 | 43 | 12 741 | + | 32 371 | 43 | 42 119 | 43 | 42 043 | 076 |
| " 22 | 43 | 14 338 | 43 | 14 182 | + | 3 145 | + | 31 090 | 43 | 41 967 | 078 |
| " 23 | 43 | 40 951 | 43 | 40 804 | + | 3 296 | + | 42 085 | 43 | 41 958 | 041 |
| June 23 | 43 | 40 951 | 43 | 40 804 | + | 6 260 | + | 42 085 | 43 | 41 958 | 073 |
| " 24 | 43 | 18 735 | 43 | 18 575 | + | 6 338 | + | 42 159 | 43 | 41 969 | 026 |
| " 25 | 43 | 08 121 | 43 | 07 956 | + | 29 702 | + | 42 159 | 43 | 42 032 | 080 |
| " 26 | 43 | 08 121 | 43 | 07 956 | + | 40 485 | + | 42 197 | 43 | 42 114 | 082 |
| " 27 | 43 | 10 311 | 43 | 10 185 | + | 6 419 | + | 42 077 | 43 | 41 961 | 063 |
| " 27 | | | | | + | 6 553 | + | 42 077 | 43 | 42 014 | 039 |

$d\lambda$ h m s
 λ Ottawa 43 42 053
 λ Moncton 5 02 51 797
 λ Moncton 4 19 09 744

OBSERVERS { R. M. STEWART.
 West—C. C. SMITH.
 D. B. NUGENT.
 East—C. A. FROESCH, in May.
 W. C. JACQUES, in June.

9-10 EDWARD VII., A. 1910

DIFFERENCE OF LONGITUDE BETWEEN FORT FRANCES, ONT., AND DOMINION OBSERVATORY, OTTAWA.

| DATE. | DIFFERENCE OF CHRONOGRAPH. | | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | | | Type of Transmission. | | | | | | |
|-------------------|----------------------------|----|------------------|-------------------|------------------|--------------------------|---------|------------------|----|--------|---|-----------------------|--------|---|----|--------|-------|-----|
| | Western Signals. | | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | | Eastern Signals. | | Mean. | v | | | | | | | |
| | h | m | s | h | m | s | h | m | s | h | | | m | s | | | | |
| 1908. | | | | | | | | | | | | | | | | | | |
| June 21 | 1 | 10 | 53.779 | 1 | 10 | 53.544 | +15.269 | 1 | 10 | 44.885 | 1 | 10 | 44.690 | 1 | 10 | 44.717 | +0.20 | 117 |
| " 25 | 1 | 10 | 52.468 | 1 | 10 | 52.230 | +13.949 | 1 | 10 | 44.857 | 1 | 10 | 44.919 | 1 | 10 | 44.738 | +0.41 | 119 |
| " 26 | 1 | 10 | 50.396 | 1 | 10 | 50.055 | +11.973 | 1 | 10 | 44.752 | 1 | 10 | 44.501 | 1 | 10 | 44.627 | +0.70 | 120 |
| " 27 | 1 | 10 | 47.587 | 1 | 10 | 47.395 | +9.227 | 1 | 10 | 44.913 | 1 | 10 | 44.632 | 1 | 10 | 44.772 | +0.75 | 120 |
| " 28 | 1 | 10 | 45.293 | 1 | 10 | 44.967 | +7.129 | 1 | 10 | 44.751 | 1 | 10 | 44.569 | 1 | 10 | 44.630 | +0.67 | 121 |

Observers (West—F. A. McDiarmid,
(East—R. M. Stewart, D. B. Nugent, C. G. Smith.

dA... .. h m s
 A Ottawa... .. 1 10 44.697
 A Fort Frances... .. 5 02 51.797
 A Fort Frances... .. 6 13 36.494

DIFFERENCE OF LONGITUDE BETWEEN NORTH LAKE, ONT., AND DOMINION OBSERVATORY, OTTAWA.

| DATE. | DIFFERENCE OF CHRONOMETER. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of Transmission. |
|-------------|----------------------------|------------------|-------------------|------------------|--------------------------|------------------|-----------|------|-----------------------|
| | Western Signals. | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | Eastern Signals. | Mean. | v. | |
| 1908. | m. s. | m. s. | s. | s. | m. s. | m. s. | m. s. | s. | s. |
| July 1..... | 58 10 942 | 58 10 711 | 42 092 | + 6 862 | 59 00 496 | 59 00 295 | 59 00 395 | -008 | 100 |
| " 2..... | 58 10 603 | 58 10 290 | 42 885 | + 6 929 | 59 00 408 | 59 00 195 | 59 00 302 | -005 | 107 |
| " 3..... | 58 09 864 | 58 09 623 | 43 529 | + 6 977 | 59 00 370 | 59 00 159 | 59 00 265 | -042 | 106 |
| " 3..... | 58 09 547 | 58 09 327 | 43 843 | + 6 987 | 59 00 377 | 59 00 157 | 59 00 267 | -040 | 110 |

$d \lambda$ h m. s.
 λ Ottawa 5 02 51.797
 λ North Lake 6 01 52.104

Observers { West—F. A. McDiarmid.
 { East—C. C. Smith, R. M. Stewart.

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN NIPUGON, ONT., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO- GRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | Time of Trans- mission. | | |
|----------------|---------------------------------|--------|---------------------|--------|---------------------|--------|---------------------|----|--------------------------|--------|---------------------|--------|----------------------------------|--------|-----|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | | Mean. | s. |
| | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | | | |
| 1908. | | | | | | | | | | | | | | | |
| July 6 | 45 | 57.114 | 45 | 56.886 | - 4 | 07.292 | + 7.110 | | 50 | 11.426 | 50 | 11.198 | 50 | 11.312 | 111 |
| " 7 | 45 | 55.976 | 45 | 55.755 | - 4 | 08.247 | + 7.178 | | 50 | 11.401 | 50 | 11.180 | 50 | 11.291 | 111 |
| " 8 | 45 | 54.340 | 45 | 54.093 | - 4 | 09.833 | + 7.245 | | 50 | 11.418 | 50 | 11.171 | 50 | 11.285 | 121 |

$d\lambda$ h. m. s.
 A Ottawa. 5 02 51.797
 A Nipigon 5 58 03.026

Observers { West—F. A. McDIARMID.
 { East—C. C. SMITH.

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN HALIFAX, N.S. AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO- GRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of Trans- mission. |
|---------|---------------------------------|---------|-------------------|-------------|--------------------------|--------|------------------|--------|----------------------------------|
| | Western Signals. | | Eastern Signals. | | Western Signals. | | Eastern Signals. | | |
| | m. | s. | m. | s. | m. | s. | m. | s. | |
| 1908. | | | | | | | | | |
| July 23 | 50 | 38 37.2 | | | 48 | 27 246 | 48 | 26 988 | 124 |
| " 24 | 50 | 39 62.9 | + 7 42.2 | - 2 03 50.4 | 48 | 27 232 | 48 | 27 037 | 097 |
| " 26 | 48 | 37 90.4 | + 7 41.2 | - 2 04 7.85 | 48 | 27 181 | 48 | 26 992 | 095 |
| " 28 | 48 | 39 99.2 | + 7 40.3 | 03 22.0 | 48 | 27 218 | 48 | 27 032 | 093 |
| " 29 | 48 | 40 65.5 | + 7 29.9 | 05 47.5 | 48 | 27 177 | 48 | 27 017 | 089 |
| " 30 | 48 | 40 65.5 | + 7 29.7 | 06 21.1 | 48 | 27 177 | 48 | 27 017 | 089 |

Observers : { West - C. C. SMITH, D. B. NUGENT, R. M. STEWART.
 { East - W. C. JAQUES.

d A h. m. s.
 A Ottawa 5 02 51.797
 A Halifax 4 14 24.684

DIFFERENCE OF LONGITUDE BETWEEN MATHESON, ONT., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | Difference of Chronograph. | | Clock Correction. | | Difference of Longitude. | | | Time of Trans- mission. |
|-------------------|----------------------------|------------------|-------------------|------------------|--------------------------|------------------|-----------|----------------------------|
| | | | | | | | | |
| | Western Signals. | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | Eastern Signals. | Mean. | |
| 1908. | m | n | m | n | m | n | m | n |
| July 22 | 20 16 678 | 20 16 573 | + 1 24 354 | + 7 633 | 18 59 457 | 18 59 862 | 18 59 904 | 438 |
| " 23 | 20 14 931 | 20 11 809 | + 1 22 712 | + 7 622 | 18 59 901 | 18 59 719 | 18 59 810 | 456 |
| " 24 | 20 13 231 | 20 13 046 | + 1 20 883 | + 7 613 | 18 59 960 | 18 59 775 | 18 59 868 | 602 |
| " 25 | 20 11 010 | 20 10 854 | + 1 18 585 | + 7 575 | 18 59 090 | 18 59 854 | 18 59 927 | 661 |
| " 26 | 20 08 557 | 20 08 389 | + 1 16 157 | + 7 503 | 18 59 903 | 18 59 735 | 18 59 819 | 747 |

Observers: West—F. A. McDIARMID.
East—C. C. SMITH.
R. M. STEWART.

d A h m s
A Ottawa 18 59 866
A Matheson 02 51 797
A Matheson 5 21 51 683

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN NEWCASTLE, N.B., AND DOMINION OBSERVATORY, OTTAWA.

| Date | DIFFERENCE OF CHRONOGRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | Time of Trans- mission. |
|--------|----------------------------|---------------------|---------------------|---------------------|--------------------------|-----------|---------------------|----------------------------|
| | Western Signals. | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | Mean. | Eastern Signals. | |
| | m s | m s | s | s | m s | m s | m s | s |
| 1908. | | | | | | | | |
| Aug. 3 | 40 35 246 | 40 35 107 | + 7 506 | + 6 129 | 40 33 869 | 40 33 800 | 40 33 730 | .070 |
| " 9 | 40 45 090 | 40 44 932 | + 7 997 | + 3 299 | 40 33 884 | 40 33 805 | 40 33 726 | .079 |
| " 10 | 40 46 185 | 40 45 993 | + 8 061 | - 4 361 | 40 33 753 | 40 33 667 | 40 33 571 | .096 |
| " 11 | 40 47 287 | 40 47 113 | + 8 124 | - 5 335 | 40 33 828 | 40 33 741 | 40 33 654 | .087 |
| " 15 | 40 52 983 | 40 52 794 | + 8 322 | - 10 794 | 40 33 867 | 40 33 773 | 40 33 678 | .093 |
| " 16 | 40 53 190 | 40 52 995 | + 8 365 | - 11 037 | 40 33 788 | 40 33 691 | 40 33 593 | .098 |

$d \lambda$ h m s
 λ Ottawa 40 33 746
 λ Newcastle 5 02 51 797
 λ Newcastle 4 22 18 061

Observers: West—R. M. STEWART, C. C. SMITH, D. B. NUGENT.
 " East—W. C. JACQUES.

DIFFERENCE OF LONGITUDE BETWEEN MEGANTIC, QUE., AND DOMINION OBSERVATORY, OTTAWA.

| DATE. | DIFFERENCE OF CHRONOGRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of transmission. |
|--------|----------------------------|--------|-------------------|--------|--------------------------|--------|------------------|--------|-----------------------|
| | Western Signals. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | |
| | m | s | m | s | m | s | m | s | |
| 1908. | | | | | | | | | |
| Aug. 4 | 18 | 26 404 | 18 | 26 271 | 19 | 19 733 | 19 | 19 690 | 077 |
| " 7 | 18 | 34 469 | 18 | 34 348 | 19 | 19 815 | 19 | 19 694 | 070 |
| " 8 | 18 | 36 718 | 18 | 36 650 | 19 | 19 825 | 19 | 19 791 | 064 |
| " 9 | 18 | 39 347 | 18 | 39 284 | 19 | 19 782 | 19 | 19 710 | 071 |
| " 10 | 18 | 41 573 | 18 | 41 438 | 19 | 19 758 | 19 | 19 691 | 068 |

h m s
 19 19 725
 5 02 51 797
 4 43 32 072

Observers: West—R. M. STEWART, C. G. SMITH, D. B. NUGENT.
 East—F. A. McDIARMID.

d A.
 A Ottawa.
 A Magnetic.

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN BLACK LAKE, QUE., AND DOMINION OBSERVATORY, OTTAWA.

| DATE. | DIFFERENCE OF CHRONOGRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of Transmission. |
|---------------|----------------------------|------------------|-------------------|------------------|--------------------------|------------------|-----------|-------|-----------------------|
| | Western Signals. | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | Eastern Signals. | Mean. | μ | |
| 1908. | m s | m s | s | s | m s | m s | m s | | s |
| Aug. 11 | 18 39 886 | 18 30 761 | +8 124 | -55 479 | 17 27 283 | 17 27 158 | 17 27 221 | - 009 | .063 |
| " 14 | 18 36 997 | 18 36 838 | +8 295 | -61 379 | 17 27 332 | 17 27 173 | 17 27 252 | -022 | .079 |
| " 15 | 18 38 713 | 18 38 571 | +8 322 | -63 085 | 17 27 306 | 17 27 164 | 17 27 235 | .065 | .071 |
| " 16 | 18 39 541 | 18 39 422 | +8 365 | -63 905 | 17 27 271 | 17 27 152 | 17 27 212 | - 018 | .080 |

$d\lambda$ h m s
 λ Ottawa 5 02 51.797
 λ Black Lake 4 45 24.567

Observers : West—D. B. NUGENT, C. C. SMITH.
 East—F. A. McDIARMID.

DIFFERENCE OF LONGITUDE BETWEEN FOSTER, QUE., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO-GRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | Time of Trans- mission. | | |
|---------|-----------------------------|--------|------------------|---------|-------------------|----------|------------------|----|--------------------------|--------|------------------|--------|-------------------------|--------|------|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | | Mean. | P. |
| | m. | s. | m. | s. | s. | s. | s. | s. | m. | s. | m. | s. | | | |
| 1908. | | | | | | | | | | | | | | | |
| Aug. 17 | 13 | 34.669 | 13 | 34.7588 | + 8.408 | - 33.484 | | | 12 | 52.777 | 12 | 52.706 | 12 | 52.742 | .036 |
| " 18 | 13 | 36.332 | 13 | 36.250 | + 8.413 | 35.147 | | | 12 | 52.779 | 12 | 52.690 | 12 | 52.731 | .041 |
| " 19 | 13 | 37.618 | 13 | 37.546 | + 8.529 | - 36.332 | | | 12 | 52.757 | 12 | 52.685 | 12 | 52.721 | .036 |

d N h. m. s.
 N Ottawa 12 52.731
 N Foster 5 02 51.797
 4 49 59.066

Observers: West—C. C. SMITH, D. B. NUGENT.
 East—F. A. McDIARMID.

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN BOUESTOWN, N.E., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO-GRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | Time of Trans- mission. | | |
|---------|-----------------------------|--------|------------------|--------|-------------------|----------|------------------|--------|--------------------------|--------|------------------|--------|-------------------------|-------|------|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | | Mean. | v. |
| | m. | s. | m. | s. | s. | s. | m. | s. | m. | s. | m. | s. | | | |
| 1 08. | | | | | | | | | | | | | | | s. |
| Aug. 20 | 37 | 27 414 | 37 | 27 220 | + 8 569 | - 08 003 | 37 | 10 842 | 37 | 10 648 | 37 | 10 745 | | .044 | .097 |
| " 21 | 37 | 27 398 | 37 | 27 220 | + 8 610 | - 07 916 | 37 | 10 872 | 37 | 10 694 | 37 | 10 783 | | .006 | .089 |
| " 22 | 37 | 29 741 | 37 | 29 560 | + 8 642 | - 10 154 | 37 | 10 945 | 37 | 10 764 | 37 | 10 854 | | .065 | .090 |
| " 24 | 37 | 30 028 | 37 | 29 882 | + 8 718 | - 10 464 | 37 | 10 846 | 37 | 10 700 | 37 | 10 773 | | .016 | .073 |
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h. m. s.
 d A 37 10 789
 A Ottawa 5 02 51 797
 A Boiestown 1 25 41 008

Observers: West—D. B. NUGENT, C. C. SMITH, R. M. STEWART.
 East—W. C. JACQUES.

DIFFERENCE OF LONGITUDE BETWEEN WOODSTOCK, N.B. AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO-GRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | | | Time of Transmission. | |
|---------|-----------------------------|--------|------------------|--------|-------------------|----|------------------|------------|--------------------------|--------|------------------|--------|-------|--------|-----------------------|-----|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | Mean. | r. | | |
| | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | | | | |
| 1908. | | | | | | | | | | | | | | | | |
| Aug. 23 | 24 | 32 513 | 28 | 32 280 | | | + 8 612 | + 1 09 028 | 32 | 32 899 | 32 | 32 666 | 32 | 32 783 | 665 | 117 |
| " 24 | 28 | 33 294 | 28 | 33 028 | | | 18 717 | + 1 08 377 | 32 | 32 891 | 32 | 32 688 | 32 | 32 791 | 013 | 163 |
| " 25 | 28 | 33 843 | 28 | 33 620 | | | + 8 778 | + 1 07 806 | 32 | 32 871 | 32 | 32 648 | 32 | 32 760 | 018 | 112 |

h. m. s.

d A

A Ottawa

A Woodstock

Observers: (West—R. M. STEWART, G. C. SMITH, D. E. NUGENT.

(East—F. A. McDIARMID.

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN ST. HYACINTHE, QUE. AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONOMETER. | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | Time of Transmission. | | | |
|---------|----------------------------|--------|-------------------|--------|------------------|----|--------------------------|----|------------------|----|-----------------------|------------------|--------|------|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | | Eastern Signals. | | |
| | m. | s. | m. | s. | m. | s. | m. | s. | m. | s. | | m. | s. | |
| 1908. | | | | | | | | | | | | | | |
| Aug. 27 | 12 | 37.653 | 12 | 37.590 | + 8.804 | 1 | 21.387 | 11 | 07.462 | 11 | 07.389 | 11 | 07.426 | .037 |
| " 28 | 12 | 38.816 | 12 | 38.748 | + 8.807 | 1 | 22.530 | 11 | 07.479 | 11 | 07.411 | 11 | 07.445 | .034 |
| " 30 | 12 | 42.103 | 12 | 42.036 | + 8.837 | 1 | 25.733 | 11 | 07.533 | 11 | 07.466 | 11 | 07.499 | .033 |

$d \lambda$ h. m. s.
 λ Ottawa 5 02 51.797
 λ St. Hyacinthe 4 51 44.340

Observers: { West—D. B. NUGENT, C. C. SMITH, R. M. STEWART.
 { East—F. A. McDIARMID.

DIFFERENCE OF LONGITUDE BETWEEN FREDERICTON, N.B., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONOGRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | Time of Trans- mission. | | |
|----------|----------------------------|--------|------------------|--------|-------------------|--------|------------------|--------|--------------------------|--------|------------------|--------|-------------------------|-------|----|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | | Mean. | S. |
| | m. | s. | m. | s. | N. | S. | N. | S. | m. | s. | m. | s. | | | |
| 1908. | | | | | | | | | | | | | | | |
| Aug. 28. | 36 | 24.603 | 36 | 24.438 | +8.897 | +2.544 | 36 | 18.340 | 36 | 18.175 | 36 | 18.258 | | 083 | |
| " 29. | 36 | 25.485 | 36 | 25.327 | +8.822 | +1.597 | 36 | 18.290 | 36 | 18.102 | 36 | 18.181 | | 079 | |
| " 30. | 36 | 26.489 | 36 | 26.370 | +8.837 | +0.615 | 36 | 18.267 | 36 | 18.148 | 36 | 18.297 | | 059 | |
| " 31. | 36 | 27.449 | 36 | 27.390 | +8.876 | 0.335 | 36 | 18.238 | 36 | 18.089 | 36 | 18.164 | | 075 | |
| Sept. 1. | 36 | 28.746 | 36 | 28.598 | +8.914 | 1.469 | 36 | 18.363 | 35 | 18.215 | 36 | 18.289 | | 074 | |
| " 3. | 36 | 31.437 | 36 | 31.304 | +8.989 | 4.171 | 36 | 18.277 | 36 | 18.144 | 36 | 18.211 | | 067 | |

Observers: West—C. C. SMITH, D. B. NUGENT, R. M. STEWART.
East—W. C. JAGUES.

d A.... h. m. s.
A Ottawa 36 18.218
A Fredericton 4 26 33.579

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN SOREL, QUE., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONOGRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of Transmission. |
|----------|----------------------------|------------------|-------------------|------------------|--------------------------|------------------|-----------|----|-----------------------|
| | Western Signals. | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | Eastern Signals. | Mean. | P. | |
| | m. s. | m. s. | s. | s. | m. s. | m. s. | m. s. | | s. |
| 1908. | | | | | | | | | |
| Aug. 31. | 10 35.736 | 10 35.677 | +8.876 | 2.701 | 10 24.159 | 10 24.100 | 10 24.130 | | .030 |
| Sept. 1. | 10 37.509 | 10 37.467 | +8.914 | 4.473 | 10 24.122 | 10 24.080 | 10 24.101 | | .031 |
| " 2. | 10 39.562 | 10 39.513 | +8.951 | 6.494 | 10 24.117 | 10 24.068 | 10 24.093 | | .025 |
| " 3. | 10 40.755 | 10 40.733 | +8.989 | 7.661 | 10 24.105 | 10 24.083 | 10 24.094 | | .011 |

h. m. s.
 d A. 10 24 107
 A Ottawa ... 5 02 51.797
 A Sorel ... 4 52 27.690

Observers: West—C. SMITH, D. B. NUGENT.
 East—F. A. McLEARN.

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN RIVIERE DU LOUP STATION., QUE., AND DOMINION OBSERVATORY, OTTAWA.

| DATE. | DIFFERENCE OF CHRONOGRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of Trans- mission. |
|--------|----------------------------|-----------|-------------------|--------|--------------------------|-----------|------------------|-------|-------------------------|
| | Western Signals. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | |
| | M. | S. | M. | S. | M. | S. | M. | S. | |
| 1908. | | | | | | | | | |
| Sept 8 | 24 57 461 | 24 57 827 | + 9 192 | 03 096 | 24 45 673 | 24 45 549 | 24 45 611 | - 024 | 062 |
| " 9 | 24 58 218 | 24 58 117 | + 9 296 | 03 237 | 24 45 725 | 24 45 624 | 24 45 674 | - 039 | 050 |
| " 10 | 25 00 319 | 25 00 211 | + 9 329 | 05 236 | 24 45 763 | 24 45 656 | 24 45 709 | - 074 | 054 |
| " 11 | 25 01 620 | 25 01 557 | + 9 383 | 06 574 | 24 45 683 | 24 45 600 | 24 45 647 | - 012 | 047 |
| " 12 | 25 02 291 | 25 02 175 | + 9 388 | 07 258 | 24 45 645 | 24 45 529 | 24 45 587 | - 048 | 058 |
| " 13 | 25 03 361 | 25 03 428 | + 9 437 | 08 478 | 24 45 646 | 24 45 513 | 24 45 580 | - 055 | 067 |

Observers : West D. B. NUGENT, C. C. SMITH.
East—W. C. JAGUES.

d λ..... h. m. s.
 λ Ottawa..... 5 02 51.797
 λ Rivière du Loup Station .. 1 38 06.162

DIFFERENCE OF LONGITUDE BETWEEN EDMUNDSTON, N.B., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO-GRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of Trans- mission. |
|--------------------|-----------------------------|------------------|-------------------|------------------|--------------------------|------------------|-----------|------|-------------------------|
| | Western Signals. | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | Eastern Signals. | Mean. | C. | |
| 1908. | m. | s. | m. | s. | m. | s. | m. | s. | s. |
| September 19 | 29 46 624 | 29 46 516 | +9 680 | 03 297 | 29 33 647 | 29 33 539 | 29 33 583 | -073 | 054 |
| " 20 | 29 44 051 | 29 43 950 | +9 627 | -00 708 | 29 33 716 | 29 33 615 | 29 33 665 | -001 | -050 |
| " 22 | 29 42 765 | 29 42 606 | +9 664 | +00 021 | 29 33 732 | 29 33 653 | 29 33 687 | -021 | 034 |
| " 23 | 29 42 736 | 29 42 645 | +9 678 | +00 706 | 29 33 751 | 29 33 673 | 29 33 718 | 002 | -045 |

Observers: West—D. B. NUGENT, R. M. STEWART, C. C. SMITH.
East—W. C. JACQUES.

d A h. m. s.
A Ottawa 5 02 51.797
A Edmundston 4 33 18.131

SESSIONAL PAPER No. 25a

DIFFERENCE OF LONGITUDE BETWEEN PERCÉ, QUE., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONO- GRAPH. | | | | CLOCK CORRECTION. | | | | DIFFERENCE OF LONGITUDE. | | | | | | Time of Trans- mission. | | |
|------------|---------------------------------|--------|---------------------|--------|---------------------|----|---------------------|----|--------------------------|--------|---------------------|--------|-------|--------|----------------------------------|------|------|
| | Western Signals. | | Eastern Signals. | | Western Station. | | Eastern Station. | | Western Signals. | | Eastern Signals. | | Mean. | | | v. | |
| | m. | s. | m. | s. | s. | s. | s. | s. | m. | s. | m. | s. | m. | s. | | | |
| 1906. | | | | | | | | | | | | | | | | | |
| October 5. | 46 | 00.841 | 46 | 00.632 | +10.660 | | +8.512 | | 45 | 59.303 | 45 | 59.094 | 45 | 59.199 | | .017 | .105 |
| " 6. | 46 | 00.161 | 45 | 59.355 | +10.072 | | +9.215 | | 45 | 59.304 | 45 | 59.098 | 45 | 59.201 | | .019 | .103 |
| " 7. | 45 | 59.666 | 45 | 59.456 | +10.078 | | +9.664 | | 45 | 59.252 | 45 | 59.042 | 45 | 59.147 | | .035 | .105 |

h. m. s.
 $d\lambda$ 45 59 182
 λ Ottawa..... 5 02 51.797
 λ Percé..... 4 16 52.615

Observers: West—C. C. SMITH, D. B. NUGENT.
 East—W. C. JACQUES.

DIFFERENCE OF LONGITUDE BETWEEN CAMPBELLTON, N.B., AND DOMINION OBSERVATORY, OTTAWA.

| Date. | DIFFERENCE OF CHRONOGRAPH. | | CLOCK CORRECTION. | | DIFFERENCE OF LONGITUDE. | | | | Time of Transmission. |
|---------------|----------------------------|------------------|-------------------|------------------|--------------------------|------------------|-------|-----------|-----------------------|
| | Western Signals. | Eastern Signals. | Western Station. | Eastern Station. | Western Signals. | Eastern Signals. | Mean. | λ | |
| 1908. | m | s | m | s | m | s | m | s | s |
| Oct. 10 | 36 | 42.680 | | | 36 | 10.171 | 36 | 10.041 | 065 |
| " 12 | 35 | 56.874 | + 42.351 | + 9.842 | 36 | 10.193 | 36 | 10.019 | 087 |
| " 13 | 35 | 54.329 | 00.792 | + 13.711 | 36 | 10.335 | 36 | 10.164 | 087 |
| " 14 | 35 | 53.985 | 00.407 | + 16.422 | 36 | 10.278 | 36 | 10.250 | 086 |
| | | | 00.400 | + 16.753 | 36 | 10.278 | 36 | 10.189 | 088 |

Observers: West—C. C. SMITH, R. M. STEWART, D. B. NUGENT.
East.—W. C. JACQUEL.

$d \lambda$

| | | | |
|-----------------------------|---|----|--------|
| λ Ottawa | h | m | s |
| λ Campbellton | 5 | 02 | 51.797 |
| | 4 | 25 | 41.634 |

SESSIONAL PAPER No. 25a

LONGITUDE AND LATITUDE OF STATIONS OBSERVED IN 1905.

| Place. | Difference of Longitude. | To | Longitude. | Longitude. | Latitude. |
|------------------------------|--------------------------|-----------------------|-------------|--------------|-------------|
| h. m. | h. m. | | | | |
| Gateway..... | 28 39 169 | Seattle. | 7 40 41 075 | 115 10 16 13 | 48 59 58 45 |
| Boundary (Waneta)..... | 18 49 289 | " | 7 50 30 983 | 117 37 44 78 | 49 00 00 55 |
| St. John..... | 38 35 784 | Dauntion Observatory. | 4 24 16 013 | 66 04 00 20 | 45 16 35 04 |
| Sprague..... | 1 19 41 569 | " | 6 22 33 396 | 95 38 20 49 | 49 02 05 10 |
| Rainy River..... | 1 15 24 072 | " | 6 18 15 869 | 94 83 58 04 | 48 43 22 80 |
| Moncton..... | 43 42 053 | " | 4 19 09 744 | 64 47 26 16 | 46 05 02 21 |
| Fort Frances..... | 1 10 44 697 | " | 6 13 36 494 | 93 24 07 41 | 48 36 48 50 |
| Turo..... | 49 46 754 | " | 4 13 05 043 | 63 16 15 65 | 45 21 47 32 |
| North Lake..... | 50 00 307 | " | 6 01 52 104 | 90 28 01 56 | 48 04 28 77 |
| Nipigon..... | 50 11 299 | " | 5 53 03 096 | 88 15 46 44 | 49 00 43 75 |
| Jackfish..... | 45 01 729 | " | 4 47 53 526 | 86 58 22 80 | 48 47 44 84 |
| Halifax..... | 48 27 113 | " | 4 14 24 684 | 63 36 10 26 | 44 40 07 52 |
| Matheson..... | 18 59 896 | " | 5 21 51 063 | 80 27 54 95 | 48 32 07 23 |
| Newcastle..... | 40 33 746 | " | 4 22 18 031 | 65 34 30 77 | 47 00 11 37 |
| Megantic..... | 19 19 725 | " | 4 43 32 072 | 70 53 01 08 | 45 34 32 80 |
| Black Lake..... | 17 27 230 | " | 4 45 24 567 | 71 21 08 51 | 46 02 44 59 |
| Porter..... | 12 52 731 | " | 4 49 59 066 | 72 29 45 99 | 45 17 14 63 |
| Boston..... | 37 10 789 | " | 4 25 41 068 | 66 25 15 12 | 46 27 18 52 |
| Woodstock..... | 32 32 778 | " | 4 30 19 019 | 67 34 45 29 | 46 08 33 28 |
| St. Hyacinthe..... | 11 07 457 | " | 4 51 44 340 | 72 56 05 10 | 45 37 15 28 |
| Fredericton..... | 36 18 218 | " | 4 26 33 579 | 66 38 23 69 | 45 57 41 30 |
| Sorel..... | 19 24 107 | " | 4 32 27 690 | 73 06 55 35 | 46 02 19 50 |
| St. Jerome..... | 6 51 983 | " | 4 38 06 162 | 73 59 57 21 | 45 46 35 20 |
| Riviere du Loup Station..... | 24 45 635 | " | 4 33 18 131 | 69 31 32 43 | 47 49 23 48 |
| Edmundson..... | 29 33 666 | " | 4 16 52 615 | 68 19 31 97 | 47 22 06 65 |
| Perce..... | 45 39 182 | " | 4 26 41 634 | 64 13 09 23 | 48 30 52 05 |
| Campbellton..... | 36 10 165 | " | | 66 40 24 51 | 48 00 31 33 |

LOCAL POSITIONS OF ASTRONOMICAL STATIONS.

Gateway.—The pier is on the international boundary line 189.4 feet due east of boundary monument No. 244, and is 541.3 feet west of United States survey post No. 25104 on boundary line.

Boundary (Waneta).—The pier is 24.5 feet due east of monument No. 181 on the international boundary line.

St. John.—The pier is 82 feet north and 171 feet west of the northeast corner of Lombard and Southwork streets. Reference point is southeast corner of I.C.R. grain elevator. Reference angle $188^{\circ}44'$ right from meridian at centre of pier to reference point. Distance, 196.8 feet.

Sprague.—The pier is 670.7 feet west and 1.4 feet north of the southwest corner of the Canadian Northern Railway station house.

Rainy River.—The pier is 111.2 feet north, and 51.3 feet west of the southwest corner of 3rd street and Atwood ave.

Moncton.—Reference point is the northwest corner of the Intercolonial Railway blacksmith shop. N. $52^{\circ}16'$ E. from meridian through centre of pier. Distance, 4.378 chains.

Fort Frances.—The pier is 9.7 feet north and 189.2 feet east of the northeast corner of 4th street and Cornwall ave.

Truro.—The pier is 49.49 feet east and 64.13 feet south of gas-pipe marking the boundary of the I.C.R. yard at head of Miller street and Mr. Fraser's gate.

North Lake.—The pier is 272.5 feet east and 15.5 south of 'frog' lying between the Port Arthur and Duluth Railway main line and the southwest leg of the 'Y.'

Nipigon.—The pier is 47.8 feet west and 82.4 feet north of the northwest corner of the Canadian Pacific Railway station house.

Jackfish.—The pier is 228.5 feet north and 82.9 feet west of the southwest corner of the Canadian Pacific Railway station house.

Halifax.—The pier is 127.26 feet east and 90.38 feet north of the southeast corner of Creighton & Co.'s grocery store. It is also 63.23 feet east and 54.04 feet south of the gas pipe marking the boundary of the I.C.R. yard. Direction of said pipe from pier being $54^{\circ}15'$ from the meridian measured from the north through the west.

Matheson.—The pier is on the right of way of the Timiskaming and Northern Ontario Railway, and is 153.5 feet south and 178.0 feet east of the northeast corner of 5th ave. and Railway street.

Newcastle.—The pier is 14.16 feet east and 90.66 feet south of the intersection of Station and Gene streets.

Megantic.—The pier is 172.5 feet east and 72.6 feet north of the southwest corner of Maple ave. and McCauley street.

Black Lake.—The pier is 111.1 feet east and 190.8 feet north of the northwest corner of Whitney ave. and the private way of the American Asbestos Company.

Foster.—The pier is 181.5 feet north and 480.3 feet west of the middle point of the crossing of the Bolton Road and the Canadian Pacific Railway main line (Foster crossing). The pier is about 80 feet north of the Canadian Pacific Railway station house.

SESSIONAL PAPER No. 25a

Boniestown.—The pier is 41.63 feet east and 90.87 feet north from the northeast corner of T. Lynch & Co.'s supply store.

Woodstock.—The pier is 432.5 feet east and 100 feet south of the northeast corner of George and Main streets.

St. Hyacinthe.—The pier is 85 feet east and 516 feet north of the middle point of the crossing of Broadway Road and the Canadian Pacific Railway main line, and is about 400 feet from the station house.

Fredericton.—The pier is on the river front 52.15 feet north and 67.0 feet west of the northwest corner of Lamont's furniture warehouse at the corner of Regent and Campbell streets.

Sorel.—The pier is 194.9 feet west and 34.2 feet north of the southeast corner of Ray and Victoria streets.

St. Jerome.—The pier is 412.0 feet east and 102.4 feet south of the southeast corner of St. Antoine and St. Anne streets. It is on the Canadian Pacific Railway right of way about 400 feet south of the station house.

Rivière du Loup Station.—The pier is 511.5 feet from the southeast corner of the I.C.R. machine shop. Angle from the north through the west $41^{\circ} 54'$.

Edmundston.—The pier is 148.30 feet east and 12.04 feet north of the northeast corner of Temiscouata Railway station.

Percé.—The pier is 84.63 feet west and 72.28 feet south of the southwest corner of Abraham Lenfesty's house.

Campbellton.—The pier is 18.27 feet east and 12.41 feet south of the southeast corner of the post office building.

Dominion Observatory.—The reference point of the longitudes observed in 1908 is a temporary transit house, the meridian of which is $0^{\circ} 12'$ east of the centre of the dome of the Observatory.

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